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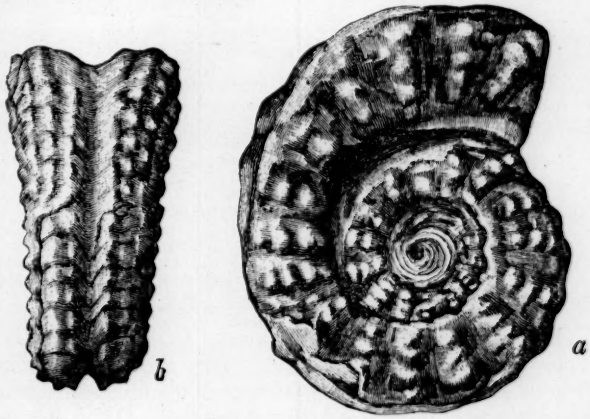
## ORIGINAL ARTICLES.

### I.—On *Pleuronautilus* [*Nautilus*] *nodoso-carinatus*, Römer, sp.

By Arthur H. Foord, F.G.S.

THROUGH the kindness of Mr. A. C. Seward, M.A., F.G.S., the British Museum has been put in possession of a fine specimen of this interesting species, collected by him in the Millstone Grit of Caton, Lancashire. The species is there found associated with *Nautilus* [*Pleuronautilus*] *armatus*, J. de C. Sowerby,[1] *Solenocheilus* [*Nautilus*] *latiseptatus*, de Koninck,[2] *Actinoceras* [*Orthoceras*] *sulcatulum*, M'Coy,[3] etc. These I have identified in a small collection submitted to me by Mr. Seward.




*Pleuronautilus nodoso-carinatus.*—*a*, lateral view, showing the ornamentation of the test; *b*, peripheral view, showing the deep median furrow, and the septa in the lower half of the figure, where the test is absent. *a*, drawn from the original specimen in the Woodwardian Museum, Cambridge; *b*, from a specimen presented to the British Museum (Nat. Hist.) by A. C. Seward, Esq., M.A., F.G.S. Both figures are about two-fifths the natural size.

From the Carboniferous Limestone, Caton, Lancashire.

[1] In Prestwich, Geology of Coalbrookdale, Trans. Geol. Soc. ser. ii. vol. v. pt. iii. p. 492, pl. xl. fig. 8, 1840.

[2] Faune du Calcaire Carbonifère de la Belgique (Ann. du Mus. Roy. d'Hist. Nat. de Belgique, tom. ii.), p. 110, pl. xxii. figs. 1–3 ? 1878.

[3] Synop. Carb. Foss. Ireland, p. 8, pl. i. fig. 4, 1844.

*Actinoceras sulcatulum* and *Solenocheilus latiseptatus* are common in the Cement-stone (Upper division of the Carboniferous Limestone) of the West of Scotland. I have myself collected them in the Arden Quarry, at Nitshill, near Glasgow (see Cat. Foss. Ceph. Brit. Mus. (Nat. Hist.), pt. i. 1888, Suppl. p. 319).

The present species has been well described, but poorly figured by Armstrong (Trans. Geol. Soc. Glasgow, vol. ii. pt. i. p. 74, pl. i. figs. 6–7) under the name of *Nautilus* (*Discites*) *nodiferus*. Its identity with Römer's species is, however, beyond question.

The following is Armstrong's description:—"Shell discoidal, composed of about three gradually enlarging, contiguous, nearly subquadrate whorls, completely exposed in a moderately shallow umbilicus; back broad, rounded at the edges, and traversed in the middle by a wide and deep channel, on the sloping sides of which are two fine thread-like ridges. The remainder of the space on the back and sides of the shell is occupied by six rows of closely set, prominent, obtuse tubercles, elongated in the direction of the aperture, one row of tubercles of large size bounding the back, a double row of equal size between it and the channel, and three on the sides, which decrease in size towards the umbilicus. Surface marked with coarse, squamose, wavy lines of growth, which are arched backwards in the dorsal [=ventral, or peripheral] channel. Septa numerous, their edges arched considerably backwards on the periphery, and slightly so at the sides. Siphuncle $\frac{1}{12}$ inch diameter, central. Dimensions—width of greatest diameter $3\frac{1}{4}$ inches, width of outer whorl near the aperture, 1 inch."

The specimen presented by Mr. Seward is a valuable accession to the British Museum collection, which hitherto possessed only some small fragments of this beautiful species. These are described in part ii. of the Catalogue of Fossil Cephalopoda (1891), p. 139, where also Armstrong's description of the species is quoted.

## II.—On some Recent Contributions to Precambrian Geology.

By J. F. Blake, M.A., F.G.S.

THE last two numbers of the Quarterly Journal of the Geological Society contain three communications concerning rocks which are, or are thought to be, Precambrian. Two of them are in direct attack on work of mine, and the third incidentally opposes some portion of it. The materials of any reply I may have to make are, for the most part, already published in my papers, but the bearing of these facts seems to require to be pointed out.

Taking the communications in order, the first is the Anniversary Address of the President. In this he deals, so far as my work is concerned, first with Anglesey. Sir A. Geikie states that he was not prepared by previous writings for certain results he obtained. He was much astonished to find in central Anglesey so striking a counterpart to portions of the old gneiss of the north-west of Sutherland and Ross. Speaking of the rocks which he here refers to, I wrote, "The question is suggested whether we may not touch here a

piece of genuine Archæan."[1] This question Sir A. Geikie answers offhand—by the guidance of petrographical characters—aided by the hummocky surface of the ground, which latter, however, is not confined to Archæan gneisses. These petrographical characters I have described,[2] and state that the rocks have "much the aspect of a Highland gneiss"; but I do not think these characters may safely "be taken as a guide" to age. There is certainly at this moment a controversy whether they can be or not.

Sir Archibald then speaks as if *no* order of succession has been made out in the Anglesey rocks, and as if their metamorphism was the only argument for their Precambrian age in the strictest sense. I would point out that near Beaumaris the Lowest Cambrian has been shown to overlie them.

But the most important matter is the decision of the age of the rocks of the Northern District which the Director-General now considers to be Silurian. He states in the first place that "the necessity for inserting" the bounding "fault apart from any actual visible trace of its occurrence arose when the conclusion was arrived at that the rocks at the extreme north of Anglesey were essentially altered Cambrian rocks." That is to say, it is a theoretical fault. Dr. Callaway has given evidence for this fault, and my own statement is: "In this Northern District a very definite sequence of rocks may be demonstrated, . . . . We can follow the strike with considerable accuracy. Now, whatever part of the series we may be on from the lowest to the highest, and therefore whatever class of rock is on the northern side of the fault, as soon as we overstep that boundary we are immediately landed in black shales, which have a pretty uniform character throughout. This leaves no alternative but a fault or an unconformity; if it were an unconformity, the upper group would run parallel to the boundary, which it does not." Whoever denies this fault, let him answer this argument, and also explain how masses of Cemmaes Limestone come to be found in the basal Silurian conglomerates.

In fact, however, this line is not in modern language a fault, but a "thrust." The Director adds: "Where the supposed elliptical fault reaches the shore at Carmel's Point, the two groups of rock seem to me to follow each other in unbroken sequence." So they do to me, but things are not always what they seem. At Craig-an Knockan, Ross-shire, and elsewhere, there is an *apparent* "conformable upward succession" between Silurian rocks and the overlying gneisses. The little bands of black slate caught up in the motion in Anglesey are just what we might expect in a similar case.

Dealing next with the nature of the upper part of the rocks, some of which have yielded fossils, he states that they include "courses of black shale containing Lower Silurian Graptolites"; also "it has been supposed that the higher bands of black shale may also have been brought into their present position by faults" . . . "but this suggestion is completely disproved by the coast sections, which exhibit many thin leaves of black shale, sometimes less than an inch thick."

[1] Q.J.G.S. vol. xliv. p. 497. [2] Rep. Brit. Assoc. for 1888, p. 32.

I am not aware that there are any *courses* (in beds parallel to the rest) of black shale; the faults which let down the masses which are said to have yielded Graptolites may be *seen* on both sides. If there are thinner black shale bands which I have not observed, that is, no doubt, a point to be considered; but it could only be decisive if they contained Graptolites of known Silurian species.

The Director sums up by saying that this area "is proved by the evidence of fossils at its base, towards its centre, and at its top to belong to the Lower Silurian series." This sounds like a settled matter. But may I ask (or rather can I get an answer to the questions?) *What* is the lowest bed of the series above the Black Shales? What are the *names* of the supposed Silurian fossils it contains? and where may they be seen? All Sir A. Ramsay says is, "On the north by the shore a few poor fossils in irregular bands of limestone clearly indicate the Caradoc or Bala age of some of the beds." What are the names of the Graptolites which occur towards the centre? and what is the proof that *Orthis Bayleana* is a Bala fossil?

The arguments generally for the Monian age of these northern rocks are these: The volcanic group is more or less repeated in various parts of the island. It must be admitted, however, that those that most resemble these northern rocks do not clearly show their stratigraphical relations. The quartz knobs and limestone masses which are found amongst them also characterize parts which are admittedly Precambrian. It may be said against this that these may be of several ages; but it is strange that they occur only in Anglesey and amongst these rocks. Bala rocks are known in the island as black shales proved to be Bala by their *named* fossils (see Mem. Geol. Survey, vol. iii. p. 225), including *Orthides*; but none of these are *O. Bayleana*, and it would be strange that the volcanic rocks of different ages should be so similar north and south, and rocks of the same age so different in the centre. If all these arguments could be met and the volcanic group were accepted as Bala, the next alternative would be that of Sir A. Ramsay, to consider part Silurian and part Cambrian, the line of separation being obliterated by the squeezing. Otherwise, if all were Bala, we should have *identical* chloritic schists at Llanflewin and Abersant, the former Bala, the latter overlaid unconformably by Arenig grit, to say nothing of *similar* rock overlaid by the same at Carmel's Point and Treiorwerth.

I have next to notice the reasons given for rejecting the term "Monian" for a series of rocks in Scotland, of which it can be written, "No one familiar with the Dalradian rocks of Scotland and Ireland can fail to be struck with the close resemblance which these younger Anglesey schists bear to them, down even to the minutest details," and "if we are justified in grouping these Anglesey rocks with the Dalradian schists." I will not say that, if by "Dalradian" is meant the whole of the seventeen groups enumerated, these reasons *as a whole* are not well founded, since in that case it may include more than one system, of which, to judge from the statements made

and if petrography can be shown in this case to be a safe guide, the Monian is certainly one. But on the next page (75) it is stated that Dalradian is proposed for the "crystalline schists" alone. In a note he says that the Monian includes Archæan gneiss. This it does not do, for if the rocks which I suggested *might* be Archæan gneiss were proved to be so, that fact would exclude them from the Monian; and if they are not Archæan gneiss they are foliated granite, and as such form no part of the system. Also that it includes "strata, volcanic and fossiliferous, of undoubtedly Bala age." But even if this could be proved, these strata could be eliminated from the Monian without destroying its existence or making it much smaller.

I now pass to the next paper by Dr. Callaway "On the Unconformities between the Rock Systems underlying the Cambrian Quartzite in Shropshire."

The first question dealt with is the age of the "Volcanic series" or Uriconian. This I concluded to be younger than the Longmynd shales. The evidence I brought forward for this was entirely original, for Dr. Callaway *never discussed the question at all*, to my knowledge, and even now he does not bring forward a shred of *positive* evidence that it is older. He says they are faulted together, in which case either might be the younger. The fact is he proved the Uriconian to be older than the Cambrian Quartzite, and *assuming* the Longmynd shales to be Cambrian also, that carried the point. Even now, I can scarcely regard its younger age as definitely proved; it may be that they are more or less contemporaneous in spite of any difference of strike. All I can say is that all the evidence available is most in favour of the volcanic series being younger; and actually Dr. Callaway's own statements are *primâ facie* to the same effect. Thus he refers to a locality on the S. E. of Ragleth (which after careful searching I failed to find) where shale like the Longmynd shale is *overlaid* by red felsite. Again, he states that near Hazler cottages the Longmynd slate near its junction with the Uriconian "has a burnt appearance and the cracks are injected with red felspar."

He next refers to the Pontesford Hill area, and says that the rocks next the rhyolite are not altered. Assuming that they are not, though to my mind they certainly are, the section is still proved by stratigraphy to lie above the whole of the Longmynd series. It is difficult to understand the gist of the concluding sentence: "As this crucial case breaks down on examination, I thought it needless to re-examine the other masses of Uriconian which appear on the line of the great Pontesford Linley fault." If it means that because in his opinion I am in error about the alteration (in common with Sir R. I. Murchison, who seems to have examined this district more thoroughly than any one else), therefore I am unworthy of credence, his paper might have conveniently stopped there.

Turning next to the unconformity in the middle of the Longmynd, he selects for sole examination the section at Narnells rock. I give the junction as it is actually seen, and this is what I say about it.

"The grit is here seen to be unconformable, but the evidence is scarcely satisfactory or conclusive. If it had been conformable, the motion which is indicated by the slickensides might easily have produced the amount of unconformity apparent." Dr. Callaway says just the same, "The grit appears to have been a little squeezed into the slate, so that here and there a trivial unconformity is apparent." According to his section, which, by the way, is not what is seen at any one spot, but is made up from several exposures, all the rocks have the same dip, so there is an apparent conformity. It is not easy to see how an apparent conformity combined with an apparent unconformity can "absolutely disprove" the reality of either one or the other. My deduction is that the evidence here is not conclusive. But other evidence is, or at least is put forward as such, but it is not tackled by the critic.

With regard to the conglomerates and grits found on the "Volcanic Hills" being superficial or otherwise, it will be well to state what I regard as evidence of a rock being superficial. When the boundary of a rock is of an irregular kind, like the outline of a map, and is surrounded on all sides by other rocks which have a more definite strike, particularly if its boundary is nearly horizontal and follows approximately the contours of the present valleys, I take it to be superficial. In proportion, of course, as these features are wanting, the evidence is less satisfactory. They are all fulfilled by the grit on Caidington Hill. I am not at all sure that Dr. Callaway has seen this patch, for the rock which composes it is *not* like the Woodgate quarry rock. As to Charlton Hill, Dr. Callaway gives a section, but this section is not seen, but inferred. The map I give is what is actually *seen*, and this proves the inference to be wrong. I am sorry to say that this map, on p. 410, is so small that it requires a lens to examine it. Small circles on it indicate exposures, and the boundary lines are drawn to include exposures of similar rock. Let Dr. Callaway show that this is wrong. It is drawn carefully to scale on the One-inch Ordnance Map, and there cannot be the slightest difficulty in knowing the exact spots intended. The same remark will apply to the two patches of igneous rock "near the south-eastern end of the Wrekin," as to which he says he is in the dark; a lens will show him *exactly* where they are on the One-inch Map.

On the crystalline rock of the Ercal, it will be sufficient to compare the two following passages: "Prof. Bonney said the rhyolite was clearly intrusive in the granitoid series" (Q.J.G.S. 1879, p. 669). "He" (Prof. Bonney) "cannot find any distinct proof of the intrusion of the felsite in the granite" (Q.J.G.S. 1891, p. 118).

Finally, with regard to the difference in strike of the rocks of the Volcanic Hills and the Longmynd rocks, it does not appear to me to be of any great consequence, and in any case does not prove the former to be older. Many of the rocks in the former have no strike at all, and the strikes noticed are very variable. Volcanic rocks, even when clastic, are apt originally to have a quâquâversal dip, and more than all, the rocks on the east side of the great fault have had to bear the brunt of all the earth-movements, and they have yielded to them in no simple way.

The third paper I wish to speak of is by Miss Raisin, "On the ower Limit of the Cambrian Series in N.W. Carnarvonshire." his I have only here to refer to as it deals with supposed *Pre-ambrian* rocks. One general observation is necessary. The uthoress continually speaks of my conclusions as "new." They re in fact essentially the conclusions of Sir A. Ramsay, and the nly novelty about them is the reconciliation of these with *some ortion* of the more recent conclusions of other writers.

The proofs which I gave of the general correctness of Sir A. amsay's conclusion Miss Raisin has sought to invalidate, and in ne case I have now to acknowledge she has done so with success. n re-visiting Bryn-Efail I find that her reading of the section is ie true one, and my own is erroneous. I would make this acknow-dgment in any case, but I do it now with all the more readiness, iat I find that the mistake is an entirely gratuitous one. If my eading had been correct, it would have constituted a difficulty, rather ian an aid in the true reading of the district.

The fact is, that when I wrote my paper I was studying Pre-ambrian rocks, and as soon as I found that there were none in the istrict—for the proof of which the other observations are amply fficient, and had led me to this conclusion before ever I saw ryn-Efail—I grudged any more time for the subject, and was glad f a short cut, which has proved to be disastrous. I saw that to nderstand the real history of these volcanic masses involved a rvey of the whole of the Cambrian rocks of the district—a task om which I shrank. That survey I have, however, now made, nd hope shortly to present the results. By this I have learnt, that great number of previous supposed results, some of my own among iem, are entirely wide of the mark. The only thing that becomes learer than ever is that there are no stratified Precambrian rocks in ie ordinary sense in North-West Carnarvonshire. These results will nder it useless to reply to any other points in Miss Raisin's paper.

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## III.—A Miniature Illustration of Normal Faulting.

By T. Mellard Reade, C.E., F.G.S.

WHEN examining the Glacial drift at Nevin, Carnarvonshire, I observed in a banded silty clay occupying the top of the cliff drift at a point between Porth Nevin and Porth Bodeilias, an xcellent illustration of my theory of Normal Faulting.[1]

The bed in question consisted of an extremely finely laminated lty clay, sometimes called book-leaf clay, the laminations being rouped in ribands about half an inch wide and six inches apart, lighter and darker colours, presenting a striped appearance very nspicuous from the shore. In the upper part of the bed the bands ere continuous, though a little wavy: the lower part of the bed, far as it was visible above the talus of sand, was faulted as own in the accompanying diagram (Fig. 1). These faults simu-ted in a remarkable manner sections of faulted coal-fields which

[1] Chap. viii. Origin of Mountain Ranges.

have been drawn from actual mining exploration and measurement. The greatest throw was $3\frac{1}{4}$ inches measured on the hade of the fault. Almost every feature of Normal Faulting was reproduced in miniature by this natural diagram, among which are the dropping of the wedge-shaped blocks (as at *e*, Fig. 1); the universal hade to the downthrow; the occasional curve of the beds (bands) downwards on one side and upwards on the other as at *fff*, the result of slipping and the tight fitting together of all the parts or wedges into which the strata have been divided by shearing.

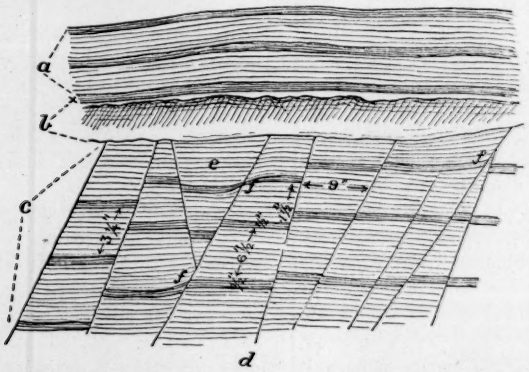


Fig. 1.—Section of faulted laminated silty clay as exposed in the Cliffs of Glacial Drift at Nevin, Carnarvonshire. Scale $\frac{1}{2}$ inch to a foot (a portion only.)

*a*. Banded laminated silty clay (unfaulted).

*b*. Cavity, the underside at × studded with hardened guttæ of sand,—the cavity in part being filled with sand.

*c*. Similar banded clay to *a*, but faulted as shown.

*d*. Talus of sand below this.

It is evident that the faulting of these banded beds is due to their contraction and loss of volume, either by actual drying or by the draining away of their water. Between the overlying unfaulted bed (*a*) and the faulted bed (*c*) there was a cavity at (*b*) six inches wide at the widest part. On the bottom or underside of the unfaulted bed at × were "guttæ" or drops of hardened sand, the underside looking as if studded with petrified raindrops. Probably this cavity was formerly a thin bed of sand which allowed the surface water percolating through the upper bed to drain away without affecting the lower bed. It is not easy to trace the exact *modus operandi* of Nature in this case, as observation was difficult from the insecure foothold on the sand talus at *d*.

An examination of the constitution of this laminated silt by breaking up six ounces of it in water and riddling it showed that a few grains of sand only were caught in a mesh of $\frac{1}{40}$ of an inch, and 10 grains by weight of sand in a mesh $\frac{1}{100}$ of an inch. All the rest passed through the $\frac{1}{100}$ inch mesh and $\frac{3}{4}$ oz. and 10 grs. were caught by precipitation.

The portion that flowed away without precipitation must have consisted largely of very small granules, probably of quartz, for the

lty clay when dry rubs on to the fingers like flour. This peculiar onstitution, together with the fine sandy laminations at which the lay readily separated, rendered the material very "short" on drying, cilitating its rupture by shearing and the keying up of its divided ortion by wedging, on the principle known to mechanics as "fox edging." If the bands were replaced in their original position, ney would not fill up the gap. The material must shrink a good eal in drying.

If we substitute volumetrical-contraction by change of temperature or contraction by loss of moisture, and increase the size, weight, nd rigidity of the beds, we have at once my theory of Normal aulting, as explained in chapter viii. of the Origin of Mountain anges. It is certainly remarkable how the material gets repacked y shearing and wedging up, even in such miniature faultings as are ere described. There are absolutely no cavities, the faults being ere lines, so close do the constituent parts fit each other. No doubt ature reproduces great faulting in this miniature manner through ne small shearing strength of the beds. Had there been more clay the material, it would have proved too plastic for the purpose. n the actual faulting of the earth's crust the weight of the rock is uch greater in proportion to the shearing stress brought into play y contraction.

In conclusion I ask, as a suggestion for the consideration of those ho have studied the subject, whether the minute faults sometimes und in banded slates have not been produced in somewhat the me manner.[1] It certainly seems clear to me that the faulting in ch cases has preceded the cleavage.

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## V.—On the Amount of Sand brought up by Lobworms to the Surface.

By Charles Davison, M.A.,

Mathematical Master at King Edward's High School, Birmingham.

TEN years ago Charles Darwin published his last work,[2] the result of more than forty years' observations on the habits of rthworms and the rate at which they bring up soil to the surface. o ascertain this rate, he made use of two methods. In the first ace he measured the rate at which layers of lime or cinders were vered over by the spread-out castings of worms; and, later, he llected and weighed all the castings thrown up over a definite ea within a given time. As is well known, the general result his investigation was greatly to exalt our ideas of the importance earthworms and of the work they do upon the surface of the land. The work performed by lobworms on the surface of tidal sands eming not less worthy of study, I made some observations on the bject during a short stay in Holy Island last August. Between is island and the opposite coast of Northumberland is an expanse

[1] See "A Faulted Slate" by J. J. Harris Teall, Geol. Mag. 1884, pp. 1, 2.

[2] "The Formation of Vegetable Mould, through the action of Worms, with servations on their Habits," 1881.

of sand (called the Holy Island Sands) about three miles wide, which is laid bare by the sea a few hours after high-water, and is then seen to be thickly studded with castings formed by lobworms. In any one spot, the castings seem to be scattered with a fair approach to uniformity, but patches of sand, apparently not differing from the rest, occur in places without any castings. When the surface is covered with broken shells, they are also rare or altogether absent, unless the sand is much ripple-marked, and then the shells collect in the hollows, while castings are common on the intervening ridges. A few observations were also made in the two bays on the north side of the island, but here the beach is more exposed, and consequently the castings, though hardly less numerous, had lost more from the action of the rougher sea.

It will be obvious that the second, but more accurate, of Mr. Darwin's methods was the only one that could be followed with profit in the present case. In several places where the castings were uniformly scattered, I marked off spaces bounded by straight lines, some of them roughly square, but the majority triangular in form. Within these spaces I counted all the castings that had been thrown up, with one exception, either about or after the time of low-tide, and from six of them filled wide-mouthed jars with castings, which were afterwards thoroughly dried and weighed.

*Number of castings in a given area.*—On the Holy Island Sands, I counted the number of castings in nineteen measured areas, all but one within the square mile, bounded on two sides by the Snook and the west coast of the island. The smallest of these areas contained 2,679 square inches, the largest 17,278; the average being 6,268 square inches, or a little less than five square yards. In order to compare the results with one another, and with those given by Mr. Darwin, I have calculated in each case the equivalent number of castings per acre. The smallest number so found is 39,935, the largest 203,272. In both these cases the castings were fairly large. In two other areas, where the castings were the largest I have seen, the numbers are 52,568 and 70,372. Taking all the 19 areas together, *the average number of castings is* 82,423 *per acre*, or more than fifty million per square mile.

On the north coast of the island there are two bays in which patches of sand occur. In each of these I counted the number of castings in three measured areas, but the numbers here given may be too small, for the castings had obviously lost much by the rougher sea, and it is possible that some were altogether obliterated. In Caves Haven, the more westerly of the two bays, the average area measured was 10,162 square inches; and the numbers of castings per acre were 86,344, 75,345 and 50,036, the average of these being 70,575 per acre. In the other bay, that to the west of Emanuel Head, the average area measured was 5,714 square inches, and the numbers of castings per acre 227,177, 65,584 and 62,114, the average being 94,466 per acre. The castings in the first of the last three areas were however small.

*Weight of the castings in a given area.*—Castings were collected

rom four areas on the Holy Island Sands with the following esults:—

(1) About 100 yards from the Holy Island shore and nearly pposite the village, a triangular area of 13,534 square inches was neasured off. It contained 87 castings, equivalent to 40,322 per cre. Sixteen of these were collected; their total weight when ried was 7,955 grains, *i.e.* an average of 497 grains or about 1¼ oz. or each casting. Now, the number of high tides in the year is 705. Hence, if the same number of castings are formed every day nroughout the year,[1] the total weight of castings thrown up nnually would be 901 tons per acre.

(2) About 100 yards from the shore and nearly opposite the ld lime-kilns, an area of 6,324 square inches contained 53 castings, e. at the rate of 52 568 per acre. These castings were all large. ix of them weighed 7,986 grains, or on an average 1,331 grains or bout 3 oz. each. The total weight thrown up annually would thus e 3,146 tons per acre.

(3) About 100 yards N.W. of the last place and the same distance rom the shore, an area of 7,844 square inches contained 88 castings, quivalent to 70,372 per acre. All of these castings were large. even of them weighed 6,963 grains, *i.e.* an average of 995 grains r about 2¼ oz. each. At this rate, the weight of sand brought up nnually would be 3,147 tons per acre.

(4) About one mile N.W. of the village and a quarter of a mile rom the shore, an area of 5,304 square inches contained 38 castings, r 44,941 per acre. These castings were very much smaller than re usually found on the Holy Island Sands, and only about half the verage number per acre. Twenty of them weighed 4,444 grains, e. an average of 222 grains or about half an ounce each; giving a tal weight ejected annually of 449 tons per acre.

Taking the average of these four estimates, we find that *the nount of sand brought up to the surface by lobworms every year is* 911 *tons per acre.*[2] But this is probably less than the actual nount; for, though the castings in the second and third areas were rger than usual, yet in the fourth they were much below the verage size, and in every case the number of castings per acre was ss, and in two cases much less, than the average number formed on e Holy Island Sands.

On the north side of the island, in Caves Haven, castings were llected from two places:

(5) An area of 12,568 square inches contained 173 castings, uivalent to 86,344 per acre. Sixty of these castings weighed

[1] I have not been able to learn anything decisive on this point, but I was informed a resident on Holy Island that the castings appeared to be quite as numerous there winter as in summer.

[2] Mr. Darwin has calculated the amount of soil brought up by earthworms in four es, one of these being near Nice and the other three in England. The results 14·58, 18·12, 7·56, and 16·1 tons per acre every year (pp. 160–169). The rage of these estimates being 14·09 tons per acre, it follows that the weight of d brought up by lobworms is 136 times the weight of soil brought up by earth-rms over an equal area in the same time.

6,119 grains; or, on an average, 102 grains or about a quarter of an ounce each. At this rate the total weight of sand brought up annually would be 396 tons per acre.

(6) An area of 13,154 square inches contained 158 castings, equivalent to 75,345 per acre. Sixty of them weighed 5,835 grains, *i.e.* an average of 97 grains or less than a quarter of an ounce for each casting. The total weight of sand brought up annually would thus amount to 329 tons per acre.

The average of these two estimates is 363 tons per acre, less than one-fifth of the average for the Holy Island Sands. But it must be much less than the amount of sand actually brought up, for the castings in Caves Haven had evidently suffered considerable degradation and some may have entirely disappeared.

*Volume of sand spread over a given area.*—After the sand from each of the six areas had been thoroughly dried and weighed, it was placed in a measuring-glass and pressed firmly down, in order to determine roughly the volume of sand brought up annually over an acre. The results are given in the following table:—

| | Volume of castings collected. c. ins. | Volume of sand brought up annually per acre. c. ft. | Thickness of the layer of sand brought up ann. ins. |
|---|---|---|---|
| (1) Holy Island Sands ... | 20·93 ..... | 21,522 ..... | 5 93 |
| (2) ,, ,, ... | 20·99 ..... | 80,815 ... .. | 22·26 |
| (3) ,, ,, ... | 18·43 ..... | 75,591 ..... | 20 82 |
| (4) ,, ,, ... | 12·02 ..... | 11,022 ..... | 3·04 |
| (5) Caves Haven ... ... | 16·48 ..... | 9,670 ..... | 2·66 |
| (6) ,, ... | 15·99 ..... | 8,192 ..... | 2·26 |

On the Holy Island Sands, therefore, the average volume of sand ejected by lobworms every year is 47,237 c. ft. per acre, and the average thickness of the layer formed by it is 13 inches. In Caves Haven, the average volume of sand ejected annually is 8,931 c. ft. per acre, and the average thickness of the layer formed by it is $2\frac{1}{2}$ inches.

Now, according to Carpenter, the depth to which lobworms burrow is from 12 to 18 inches, and according to Johnston about two feet.[1] Taking the higher of these two estimates, it follows that, in the Holy Island Sands, the layer of sand in which the lobworms live must on an average pass through their bodies once in 22 months.

*Geological work of Lobworms.*—The figures above given will show, I think, how important is the work accomplished by lobworms. We have seen that over an acre nearly two thousand tons of sand are brought up by them in the course of a year and deposited on the surface. Of course, the distance through which it is carried is not great; but, unlike most other agents of geological change, it is carried in the direction opposite to that in which gravity acts. The uppermost layer of sand must frequently pass through the bodies of lobworms, and in this way the sand-particles must become slightly

[1] Dr. W. B. Carpenter, "Zoology" (1867), vol. ii. p. 300. Dr. G. Johnston, "A Catalogue of the British Non-parasitical Worms in the Collection of the British Museum" (1865), p. 230.

worn. But this is of small importance compared with the fact that fresh sand is being continually introduced by them to the rounding action of the waves.

Nearly all castings are formed on a surface of sand which is inclined towards the sea. At the first touch of the water, a casting sinks down and swells out at the base, and more of the casting flows down the slope than up it. This flowing was especially marked at one spot on the Holy Island Sands, where the beach was slightly inclined and the surface discoloured by mud. The castings formed on it were composed of clean sand, and had evidently been surrounded by one or several waves as the tide went down. We cannot always be certain that the summit of a casting was originally above its centre, but in every one by far the greater part of the spread-out base lay below the highest point of the casting. In some cases, the castings had entirely lost their vermiform appearance, and were simply long low mounds, the longer axes pointing down the slope. In others, they had flowed so much that they could only be distinguished by their different colour from the surrounding sand.

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## V.—Note on the Occurrence of *Ammonites jurensis* in the Ironstone of the Northampton Sands in the Neighbourhood of Northampton.

By E. T. Newton, F.G.S.

CONSIDERABLE doubt having been expressed with regard to the occurrence of the zone of *Ammonites jurensis* in the neighbourhood of Northampton, much interest attaches to the discovery, by Mr. T. Jesson of Great Houghton, of the typical Ammonite in some abundance in this area. It is perhaps remarkable that there should have been any doubt about the matter, seeing that in Samuel Sharp's earlier paper[1] *Am. jurensis* was recorded among the fossils from Duston, and this should have stimulated further search when the doubt arose which seems to have caused this species to be omitted from the later paper by the same author,[2] in which some palæontological errors of the earlier paper were said to be corrected. This omission led subsequent writers to think that *Am. jurensis* did not occur in the neighbourhood, and, indeed, it does not appear to have been met with by other workers in the district until the present discovery by Mr. Jesson.

In 1874 Mr. Sharp conducted an excursion of the Geologists' Association to Northampton, and in the report of that excursion Mr. W. H. Hudleston[3] notices the section of the "ironstone series of the 'Northampton Sand'" at Duston Quarries, but does not mention *Am. jurensis* as being among the fossils found.

Mr. Beeby Thompson, in his paper on the "Upper Lias of Northamptonshire,"[4] maintains that the *Am. jurensis* zone is represented in the clayey series beneath the Northampton Ironstone, by his "Upper *Leda-ovum* beds," although the characteristic *Ammonite*

[1] Q.J.G.S. vol. xxvi. p. 354, 1870. [2] Q.J.G.S. vol. xxix. p. 296, 1873.
[3] Record of Excursions, London, 1891, p. 452.
[4] Journ. Northamptonshire Nat. Hist. Soc. vol. v. p. 54, 1888.

had not been found; this view, however, has been contested by Mr. S. S. Buckman in a later number of the same journal.

Mr. Jesson, who has been for some time collecting assiduously from the Ironstone beds in the neighbourhood of Northampton, has been kind enough to send to the Museum of Practical Geology, for examination, the series of specimens which he has obtained. These are chiefly *Ammonites*, some being from Duston, but the greater number are from Brixworth, about seven miles N. of Northampton. The species which have been determined are given in the list below, but by far the greater number of specimens from the last-named locality are referable to the two species *Am. jurensis* and *Am. opalinus*, which are about equally numerous, while each of the other species is represented by only two or three specimens. The examples which are referred to *Am. jurensis* are very uniform in character, allowance being made for variation in size; some of the smaller (which may be the middle portions of larger ones) being an inch or so in diameter, while others measure as much as six or eight inches, and there are fragments of one specimen which must have been at least 15 inches in diameter, or somewhat larger than the example in the Museum of Practical Geology, figured half its natural size by Dr. Wright,[1] with which these Brixworth Ammonites exactly agree.

The specimens which are referred to *Am. opalinus* correspond with those figured by Mr. S. S. Buckman.[2] *Am. insignis* is represented by two or three specimens in which the tubercles near the inner margin are large, and in one example (4 or 5 inches in diameter) almost obsolete. Another example has better defined tubercles, until the Ammonite is about 5 or 6 inches in diameter, but the outer whorl, which, if perfect, would be perhaps 10 inches in diameter, is nearly smooth, having almost lost both ribs and tubercles. Two or three examples of a variety of *Am. insignis* are included in this collection, which agree with that figured by Dr. Wright[3] as an abnormal young specimen.

The occurrence of *Am. jurensis*, *insignis*, *opalinus*, and *Murchisonæ* in the Northampton Ironstone would seem to indicate that the *Ammonite* zones are not so sharply defined in this area as they are considered to be in some localities in the southern and western counties; it is possible that future investigation may show the ironstone series to be divisible into definite horizons, but at present we have no evidence as to the particular part of the ironstone series from which the fossils have been derived.[4]

Fossils from the Ironstone of Brixworth.

*Ammonites jurensis.*
,, *opalinus.*
,, *insignis.*
,, ,, var.
,, *Murchisonæ.*
*Nautilus* sp.
*Belemnites* sp.
*Trigonia compta.*
,, *v. scripta.*
*Tancredia axiniformis*?

[1] Pal. Soc., Lias Ammonites, pl. lxxix.
[2] Pal. Soc. Inferior Oolite Ammonites, pl. xiii.
[3] Pal. Soc. Lias Ammonites, pl. lxxv. figs 1–3.
[4] This paper was read in Section (C) Geology, Brit. Assoc. Cardiff, Aug. 1891.

## VI.—On *Athyris læviuscula*, Sow., sp., with the Full Disclosure of its Loop, etc.

By the Rev. Norman Glass.

DAVIDSON thus describes the external characters of this species in his Sil. Suppl. pp. 101, 102. The description is practically the same as that which he previously gave in his Sil. Mon. "Marginally of a somewhat elongated, pentagonal shape, truncated, and slightly indented in front, broadest about the middle. Tapering posteriorly. Valves almost equally convex, with a slight median depression near the front in the ventral valve. Beak strongly incurved, and truncated by a minute oval foramen; surface smooth, marked by a few concentric lines of growth. Length 6, breadth 5 lines, but the generality of specimens are much smaller." Davidson refers to the spirals of this species both in his Sil. Mon. and in his Sil. Suppl. Sil. Mon. p. 115: "I had noticed the presence of spirals in 1847, and recorded the observation in the 'Bulletin Soc. Géol. France,' and Lindström has also detected them in a Gothland specimen." In pl. x. fig. 31 of his Sil. Mon. Davidson represents the dorsal aspect of the spirals, with the bases of the spirals facing each other in the centre of the shell. The spirals of this species are more fully referred to in Davidson, Sil. Suppl. p. 102: "The small dimensions attained by this species caused the Rev. Norman Glass much trouble in his patient endeavours to work out its interior arrangements. A great number of English specimens were operated upon, as well as a number of Swedish ones kindly contributed by Prof. Lindström of Stockholm. Mr. Glass has shown in a very plain manner the accessory lamellæ, also the hook-shaped attachments to the hinge-plate; but, on account of the smallness of the specimens, it was not possible to expose the loop or its attachments to the primary lamellæ in the same manner as he had so successfully achieved in *Athyris plano-sulcata*. We are both convinced that Sowerby's species is an *Athyris*. In a specimen one line and a half in length cleared out by Mr. Glass, there were only three coils in each spiral. In another four lines in length, four coils; and none of the largest specimens have shown more than six or seven in each spiral." In his Sil. Suppl. pl. iv. figs. 25, 26, Davidson gives representations of the dorsal and ventral aspects of the spirals—the ventral aspect including the hook-shaped attachments of the primary lamellæ to the hinge-plate and the accessory lamellæ of the loop.

Davidson in the above quotation credits me with a stronger impression than I possessed as to this species being an *Athyris*. Certainly so far as the hook-shaped attachments of the primary lamellæ to the hinge-plate were concerned, and the ventral aspect of the accessory lamellæ, there was nothing to distinguish this species from *Athyris*, but in *Athyris* the accessory lamellæ are continued over the posterior border and about half-way down the dorsal face of the spirals, and no evidence of this had been discovered when the Sil. Suppl. was published—indeed those preparations which had sent to Davidson showing the dorsal aspect of the spirals

exhibited no trace of this extension of the accessory lamellæ. Besides, it was evidently impossible to decide with any certainty that this species was an *Athyris* whilst the loop and its attachments to the primary lamellæ were undiscovered.

Davidson in his Sil. Mon. described three species of *Athyris*, namely *Athyris obovata*, *A. compressa*, and *A. depressa*—the latter marked by a sign of interrogation. Through his further study, however, and through my own researches, he afterwards in his Sil. Suppl. withdrew the whole of these from the generic denomination of *Athyris*. *Athyris obovata* and *A. compressa* he determined as being nothing more than modifications in shape of a single species referable to his new genus of *Glassia*, and in his Sil. Suppl. p. 155, he made the following statement as to *Athyris depressa*:—"The Rev. N. Glass was able to develop the interior, and to clear away all uncertainty as to the generic position of the shell, for it has the two short, curved lamellæ of the genus *Rhynchonella*." As therefore the only known representative left of the genus *Athyris* in the British Silurian rocks, according to Davidson in his Sil. Suppl., was *Athyris læviuscula*, and as I had many doubts at to its real generic position, I determined to avail myself of every opportunity for further investigation. And now, after the lapse of nearly ten years, and after many unsuccessful efforts to procure suitable specimens, I have at last been enabled fully and decisively to reveal the loop of this species, and thereby conclusively to prove that it cannot possibly be regarded as belonging to the genus *Athyris*.

I have to express my thanks to G. H. Maw, Esq., Benthall Works, Jackfield, Shropshire, for his great kindness in sending to me about one cwt. of blunged material from the exposure of the Tickwood beds, by the side of a small stream flowing down the east end of Benthal Edge, opposite Ironbridge. This material I found on further washing to consist of thousands of small pieces of hard rock, innumerable fragments of Corals and Encrinites, many small specimens of *Spirifera*, *Rhynchonella*, *Nucleospira*, etc., and above all a goodly number of the species for which I had been so long in search.

The following descriptions of the loop of *Athyris læviuscula*, and of the median septum in the dorsal valve which has hitherto been undiscovered, are based upon a number of my preparations, some of them very minute, and others from four to five lines in length.

Ventral aspect of the loop of *Athyris læviuscula*, Sow., sp.

The loop of *Athyris læviuscula* commences from the dorsal side of the spirals slightly above their centre, and consists of two short converging lamellæ, which arise from the primary lamellæ, and which proceed in an upward and sloping direction between the spirals and right across to their ventral side before uniting in a sharp point beneath the hook-shaped attachments to the hinge-plate. Arising from this uniting point of the loop there is a bifurcation—the two accessory lamellæ thus formed curving in an upward and backward direction to the

osterior border of the spiral. (In the accompanying sketch the rimary lamellæ and their hook-shaped attachments to the hinge-late are shown denuded of the rest of the spirals. For similar figs. f my preparations of *Whitfieldia tumida vide* Davidson, Silurian upplement, plate vi.)

The differences between the loop of this species and that of *Athyris* re thus very strongly marked. 1. Between the simple V-shaped ommencement of the loop and the bifurcation there is in *Athyris evisuscula* no roof-shaped expansion and single lamella as in the rue *Athyris*. 2. The short, converging processes which commence he loop in *Athyris lævisuscula* at once proceed in an upward direc-ion—whereas in the true *Athyris* they proceed first in a slightly ownward direction before uniting to form the roof-shaped expan-ion. 3. The accessory lamellæ at the end of the loop in *Athyris evisuscula* do not extend beyond the posterior border of the spirals, nd are not prolonged down a portion of the dorsal side of the pirals as in the true *Athyris*.

I may mention here that there is a median septum supporting the inge-plate in the dorsal valve of *Athyris lævisuscula* similar to that hich is found in *Whitfieldia tumida*. This median septum extends o a little more than one-third of the length of the shell, and is in ome cases visible when the shell is transparent. In addition, how-ver, to this evidence I have clearly proved the existence of the edian septum in *Athyris lævisuscula* by rubbing down the umbo of he dorsal valve in a rather large specimen. In this specimen the hell is destitute of spirals and filled with a light earthy matrix in hich the darker coloured median septum is very apparent. When escribing *Meristella* [*Whitfieldia*] *tumida* in his Sil. Mon. p. 110, avidson refers to the median septum of its dorsal valve as being isible through the transparent shell, and in his Sil. Suppl. pl. iv. g. 24, he represents a similar appearance in *Athyris lævisuscula*, nd yet he makes no reference to the median septum in this species, nd does not seem to have been aware of its existence.

Sowerby's *lævisuscula*, according to Davidson, has had a remarkable istory so far as the generic positions assigned to it are concerned. fter variously figuring in the works of Sowerby, Hall, Bronn, e Verneuil, D'Orbigny, Salter, Lindström and Davidson, as *Tere-atula*, *Atrypa*, *Rhynchonella*, *Meristella*, *Meristina*, *Spirigera*, and *thyris*, I think this species must now after full investigation be nally placed under Davidson's more recent genus of *Bifida—vide* avidson, Devonian Supplement, pp. 27, 28.

Both in *Bifida lepida* and in Sowerby's *lævisuscula* the simple -shaped commencement of the loop is immediately succeeded by he bifurcation without any intervention of a roof-shaped expansion nd single lamella as in *Athyris*, or of a single lamella as in *Kayseria* nd *Whitfieldia*. Davidson, in his Sil. Suppl., evidently regarded the pirals and their connexions as the principal if not the sole ground r the determination of the different genera of the spiral-bearing rachiopoda. Thus, where it was found on investigation that the pirals and loop in several different genera were in all important

respects the same, he was evidently inclined to class the whole of these genera under one generic denomination, despite their marked and manifold external differences. In his Sil. Suppl. p. 95, he says: "It will remain a question for further consideration whether we are justified in retaining the three generic denominations of *Nucleospira*, *Retzia*, and *Meristina*, for shells possessing the same simple loop." It is therefore in agreement with the principles of classification adopted by Davidson that I now place the species which Sowerby named *læviuscula* under the genus *Bifida*, of which *Bifida lepida* is the type.

P.S.—Davidson's Sil. Suppl. was issued in two portions in the Annual volumes of the Palæontographical Society for 1882 and 1883. After writing the above article I have found in the Index accompanying the latter portion of the Suppl. that Davidson ultimately had the same doubts as myself as to the true generic position of *læviuscula*. In the Index referred to—Sil. Suppl. p. 233—Davidson puts a note of interrogation to the generic name of *Athyris* as applied to *læviuscula*, and he adds concerning *Athyris*,—"It is not certain whether we possess any true British Silurian species of the genus."

## NOTICES OF MEMOIRS.

ABSTRACTS OF PAPERS READ BEFORE SECTION C. AT BRITISH ASSOCIATION MEETING, CARDIFF, August, 1891.

I.—DISCOVERY OF THE OLENELLUS-ZONE IN THE NORTH-WEST HIGHLANDS. By Sir ARCHIBALD GEIKIE, F.R.S., Director-General of the Geological Survey.

EVER since the Geological Survey began the detailed investigation of the structure of the North-west Highlands of Scotland the attention of its officers has been continuously given to the detection of any fossil evidence that would more clearly fix the geological horizons of the various sedimentary formations which overlie the Lewisian gneiss. A large collection of organic remains has been made from the Durness Limestone, but it has not yet yielded materials for a satisfactory stratigraphical correlation. The study of this collection, however, has confirmed and extended Salter's original sagacious inference that the fauna of the Durness Limestone shows a marked North American facies, though, according to our present terminology, we place this fauna in the Cambrian rather than in the Silurian system. Below the Durness Limestone lies the dolomitic and calcareous shaly group known as the 'Fucoid beds,' which, though crowded with worm-castings, has hitherto proved singularly devoid of other recognizable organic remains. In following this group southwards through the Dundonnell Forest, in the west of Ross-shire, my colleague, Mr. John Horne, found that, a few feet below where its upper limit is marked by the persistent band of 'Serpulite grit,' it includes a zone of blue or almost black shales. During a recent visit to him on his ground, when he pointed out to

ıe this remarkable zone, I was struck with the singularly unaltered haracter of these shales, and agreed with him that, if fossils were to e looked for anywhere among those ancient rocks, they should be ound here, and that the fossil collector, Mr. Arthur Macconochie, ıould be directed to search the locality with great care. The llowing week this exhaustive search was undertaken, and Mr. Iacconochie was soon rewarded by the discovery of a number of agmentary fossils, among which Mr. B. N. Peach, who was also ationed in the district, recognized what appeared to him to be un-ubtedly portions of *Olenellus*. The importance of this discovery eing obvious, the search was prosecuted vigorously, until the fossil-erous band could not be followed further without quarrying opera-ons, which in that remote and sparsely inhabited region could not e at that time undertaken. The specimens were at once forwarded me, and were placed in the hands of Messrs. Sharman and Newton, alæontologists of the Geological Survey, who confirmed the refer-ıce to *Olenellus*. More recently Mr. Peach and Mr. Horne, in a ıewed examination of the ground, have found, in another thin am of black shale interleaved in the 'Serpulite grit,' additional eces of *Olenellus*, including a fine head-shield with eyes complete. here may be more than one species of this Trilobite in these Ross-ire shales. The specific determinations and descriptions will ortly be given by Mr. Peach.

The detection of *Olenellus* among the rocks of the North-west ighlands, and its association with the abundant *Salterella* of the erpulite grit,' afford valuable materials for comparison with the dest Palæozoic rocks of other regions, particularly of North merica. The 'Fucoid beds' and 'Serpulite grit' which intervene tween the quartzite below and the Durness Limestone above are w demonstrated to belong to the lowest part of the Cambrian stem. The quartzites are shown to form the arenaceous base of at system, while the Durness Limestones may be Middle or Upper mbrian. On the other hand, the Torridon Sandstone, which urchison placed in the Cambrian series, can now be proved to be still higher antiquity. The marked unconformability which tervenes between it and the overlying quartzite points to a long terval having elapsed between the deposition of the two discordant rmations. The Torridon Sandstone must therefore be pre-Cam-ian. Among the 8,000 or 10,000 feet of strata in this group of dstones and conglomerates, there occur, especially towards the se and the top, bands of grey and dark shales, so little altered at they may be confidently expected somewhere to yield recogniz-le fossils. Already my colleagues have detected traces of annelids d some more obscure remains of other organisms in these strata. ese, the oldest relics of life yet known, have excited a vivid desire the Geological Survey to discover further and more determinable sils associated with them in the same primeval resting-place. We ll spare no pains to bring to light all that can be recovered in North-west Highlands of a pre-Cambrian fauna.

II.—A Comparison between the Rocks of South Pembrokeshire and those of North Devon. By Henry Hicks, M.D., F.R.S., Sec. Geol. Soc.

THE clear succession from the Silurian rocks to the Carboniferous to be observed in many sections in South Pembrokeshire offers, in the author's opinion, the key to the true interpretation of the succession in the rocks of North Devon, for there cannot be a doubt that the post-Carboniferous earth-movements which so powerfully affected and folded the beds in North Devon extended into and produced almost identical results in South Pembrokeshire. In the latter area, however, the succession remains clearer, and can be traced more continuously.

The base of the Silurian (Upper Silurian Survey) is exposed at many points, and the lower beds repose transgressively on the Ordovician, and even on some pre-Cambrian rocks. Near Johnston and Stoney Slade the conglomerate contains numerous pebbles of the Johnston and Great Hill granite as well as of other igneous masses which were formerly supposed to have been intrusive in these beds. From the Silurian to the Carboniferous beds there does not appear to be any marked break in the series; moreover, all these beds were folded together and suffered equally by the movements which affected the area. The axes of the folds strike from about W.N.W. to E.S.E. The movements, therefore, at this time were in a nearly opposite direction to those which affected the Ordovician and Cambrian rocks at the close of the Ordovician period. Within the broken anticlinal folds portions of the old land surfaces have been exposed in several places by denudation.

The succession exposed in this area and the effects produced by the earth-movements so nearly resemble those already described by the author as occurring in North Devon, that he is convinced that the beds must have been deposited contemporaneously in one continuous subsiding area, and that the differences recognizable are chiefly in the basal beds, which were deposited on an uneven land surface.

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III.—On the Evidences of Glacial Action in Pembrokeshire, and the Direction of Ice-flow. By Henry Hicks, M.D., F.R.S., Sec. Geol. Soc.

THE occurrence of ice-scratched rocks and of northern erratics in North-west Pembrokeshire has already been mentioned by the author, but in this paper he brings forward additional evidence to show that, during the Glacial period, a great thickness of land-ice must have passed over Pembrokeshire.

The glacial striæ, which are so well preserved under the drift along the north-west coast, especially at Whitesand Bay, show that the ice travelled over that area mainly from a north-western direction. The presence of erratics from North Wales and from Ireland would tend to the conclusion that glaciers from these areas coalesced in St. George's Channel, and that the ice which overspread Pembrokeshire was derived from both these sources, as well, probably, as from a flow extending down the channel from more northern areas.

Although there are in the district many northern erratics, notably a large boulder of granite and another of picrite, which the author found on Porthlisky farm, two miles south-west of St. David's, yet by far the majority are of local origin, and can be traced back to the parent rocks. The great igneous masses which now form such conspicuous hills along the north coast yielded most of the boulders, many of very large size, which are so freely spread over the undulating land reaching to the coast of St. Bride's Bay. There are clear evidences to show that this bay was itself overspread by a great thickness of drift from these hills. The intervening pre-glacial valleys were also filled by this drift, and the plains and rising grounds up to heights of between 300 and 400 feet still retain evidences of its former presence, and many perched blocks. Excellent sections of unstratified drift, containing large ice-scratched boulders, are exposed in Whitesand Bay, and a thickness of several feet of an irregularly stratified sand was, some time since, exposed under the Boulder-clay on the east side of the bay. Chalk flints have been found at heights of over 300 feet, having probably been brought from Ireland. The picrite boulder already referred to has been shown by Prof. Bonney to resemble masses of that rock exposed in Carnarvonshire and Anglesea, and the granite boulder, which before it was broken must have been over 7 feet in length and 3 to 4 feet in thickness, is identical with a porphyritic granite exposed in Anglesea, but not found anywhere in Pembrokeshire. The evidences, therefore, which go to prove that Pembrokeshire was buried under an ice-sheet that must have spread southwards into the Bristol Channel, are, the presence of many northern erratics, both as perched blocks and in drifts at heights above 00 feet, ice-scratched, smoothed and polished rock surfaces, and, in places, much crushing and bending of some of the strata; also great dispersions of boulders from igneous rocks on the north coast in south-west direction, and some well-marked examples of 'crag and tail.'

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## V.—Notes upon *Colobodus*, a Genus of Mesozoic Fossil Fishes.

By Montagu Browne, F.Z.S., F.G.S.

COLOBODUS appears to have been first constituted a genus in the year 1837 by Louis Agassiz (see 'Poissons Fossiles,' ome II., iie partie, p. 237), who gave this name to some *Lepidotus*-ke teeth (*Colobodus hogardi*) from the Muschelkalk, which he escribed thus:—"Par leur taille elles tiennent le milieu entre les icrodon et les Sphærodus. De formes arrondies et cylindracées rs la base, les dents ont leur couronne renflée en forme de massue, sur le milieu de la couronne s'élève encore un petit mammelon onqué, ce qui a valu à ce genre son nom de *Colobodus*."

Since that time teeth of a similar generic character have been escribed or figured by various authors, *e.g.*, Count Münster ssuming *Asterodon* to be identical), Plieninger, Giebel, Gervais, eyer, Chop, E. E. Schmid, Alberti, Eck, Winkler, Gürich, W. ames, and A. S. Woodward. The typical teeth, however—*i.e.* those

upon which the 'nipple,' or apical tubercle, is present—must be sought amongst the various species of *Colobodus* and *Lepidotus* (of Plieninger, 1847); whilst intermediate forms, or those from which the 'nipple' has been partly or entirely removed by wearing or by *post-mortem* abrasion, must be sought amongst those described under the various species of *Lepidotus*, *Sphærodus*, *Gyrodus*, '*Tetragonolepis*' (of Winkler, and of Agassiz in part), *Tholodus* and *Thelodus*, *Eupleurodus*, *Sargodon* (not cutting teeth), and even amongst teeth variously attributed to *Saurichthys* and to 'Saurians,' whilst the chisel-shaped, or pre-maxillary, teeth are probably those attributed to *Sargodon tomicus*.

Fragments of the head and trunk and scales of *Colobodus* have been described or figured by H. B. Geinitz, Meyer and Plieninger, Giebel, Meyer, Quenstedt, Eck, Kner, H. Kunisch, W. Dames, J. von Rohon, and A. S. Woodward, and must be sought amongst the various species ascribed to *Gyrolepis* and *Amblypterus*, *Lepidotus*, *Heterolepidotus*, *Eugnathus*, *Pleurolepis*, *Dactylolepis*, and also amongst various Ganoid scales ('Ganoidschuppen' and 'Fischschuppen').

Up to the present neither the teeth nor the scales of *Colobodus* have been recognized as such in Britain by any authors, or, above the Muschelkalk and Lettenkohle, abroad: its occurrence and recognition, therefore, in the Rhætic of Britain is interesting, and the author exhibits typical and transitional teeth which he found and recognized in the Rhætic 'bone-beds' of Wachet and Aust Cliff; worn and abraded teeth ('*Sargodon tomicus*' and '*Sphærodus*') from thence and from Leicestershire; and what are probably the larger cutting teeth from Aust and Leicestershire; also fine characteristic scales and (? head-)bones showing vermiculated sculpture from Aust. All may, for the present, be referred to *Colobodus maximus* (Quenstedt).

Finally, should *Colobodus* prove to be identical with *Lepidotus*, a fusion of *Heterolepidotus* and *Eugnathus* will give *Colobodus* a more extended upward range than has hitherto been supposed.

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## V.—The Ammonite Zones of Dorset and Somerset.

By S. S. Buckman, F.G.S., Hon. Memb. Yorks Phil. Soc.

THE lower part of the *Murchisonæ*-zone is often intimately connected with the upper part of the *Opalinum*-zone; but, a little higher, there is an horizon characterized by numerous specimens of *Ludwigia Murchisonæ*. The fauna of this horizon corresponds to the *Murchisonæ*-zone of Oppel, and to the Brauner Jura $\beta$ of Quenstedt. Above the *Murchisonæ*-zone a considerable break in the sequence of strata is frequently met with. In the neighbourhood of Bradford Abbas, however, is found, superior to the *Murchisonæ*-zone, an horizon marked by a very peculiar fauna, in which *Lioceras concavum* and species of the genus *Sonninia* predominate. Taken in a general sense the fauna of this zone (*Concavum*-zone) does not agree with that of Quenstedt's Brauner Jura $\beta$ or $\gamma$, nor with that of the *Sowerbyi*-zone, as illustrated by Waagen, Douville, etc. Further,

the *Sonniniæ* of the *Concavum*-zone are, biologically, of an earlier type than those of the *Sowerbyi*-zone.

Continental authors find a marked stratigraphical and palæontological break between the *Murchisonæ*- and *Sowerbyi*-zones; and they wish to draw, at this point, a dividing line between Lias and Oolite, or between Toarcian and Bajocian. It is suggested that the absence of the *Concavum*-zone is the cause of this break; and, in former papers to the Geological Society, the author, in supporting the Continental plan, regarded the *Concavum*-zone as Toarcian.

In the Bradford Abbas district there is a break above the *Concavum*-zone. So far as is known at present, Dundry is the only locality showing a complete sequence; but some years ago a quarry—Coombe, near Sherborne—was open, and it yielded a large series of Ammonites indicating a fauna agreeing with the *Sowerbyi*-zone as illustrated by Continental authors. This quarry has been closed for years; and nothing is known as to how the strata are situated with regard to the *Concavum*-zone below, or with superior horizons. It is richer than Dundry, and is, practically speaking, unique among Inferior-Oolite exposures. It is the only locality in England which yields this particular fauna. So far as is known, the true *Sowerbyi*-zone is absent from all quarries in Dorset and Somerset, with the exception of Coombe and Dundry; and, therefore, the majority of exposures in the district fully support the Continental geologists in their contention as regards a dividing line.

Waagen places a zone of *Am. Sauzei* above the *Sowerbyi*-zone; and an horizon with this species and with a particular fauna is shown in 'the marl with green grains' at Frogden quarry, near Sherborne.

Above this is the zone of *Am. Humphriesianus*, in which the fauna *Stephanoceras* and *Sphæroceras* predominate. This is the equivalent of the *Coronaten-schichten* of Quenstedt's Brauner Jura $\delta$. The upper part of the Brauner Jura $\delta$ is the Bifurcaten-schichten; and this corresponds with the *Cadomensis*-beds of Frogden—an horizon which, containing a fauna distinct from the *Humphriesianus*-zone, may therefore be known as the *Cadomensis*-zone.

The strata above this horizon have usually been called the '*Parkinsoni*-zone.' There are several objections to this name; and the strata are capable of more subdivision.

The bed at Halfway House which yields the large *Parkinsoniæ* is superior to the *Cadomensis*-zone. It may be called the *Truellii*-zone. At the top of the limestone of the Broad-Windsor district *Stephan. zigzag* and species of *Morphoceras* are found; and this is a still higher horizon (*Zigzag*-zone). Just below the Fullers' Earth of this same district, in the Fullers' Earth itself of Eype, but in the upper white limestones (about 25 feet thick) of the Bradford-Abbas district, are found *Oppelia fusca* and other species indicating a still higher horizon. It is suggested that the white limestone of the Bradford-Abbas district is contemporaneous with the so-called 'Fullers' Earth clay' of Eype. This horizon may be called the zone of *Oppelia fusca*; and whether this zone belongs to the Inferior Oolite or to the Fullers' Earth depends on whether the observer be

regarding the limestones of the Bradford-Abbas district or the clay of Eype cliff.

Several Continental geologists, however, commence the Bathonian with the *Cadomensis*-zone. To this idea the presence of *Parkinsoniæ* and other facts gives considerable support.

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VI.—On the Continuity of the Kellaways Beds over extended areas near Bedford, and on the Extension of the Fullers' Earth Works at Woburn. By A. C. Cameron. [Communicated by permission of the Director-General of the Geological Survey.]

IN this paper further evidence is submitted from different parts of the country of the continuity over extended areas of the Kellaways Rock above the Lower Oxford Clay. Several fine excavations, the result of railway enterprise, have afforded sections of these beds in places where their presence was only inferred before. More than the usual thickness is indicated by records recently obtained from deep sinkings and borings in the Midland districts, especially the Bletchley boring of 1886–7.

The extraordinary concretionary stones noticed in Wiltshire by Smith as characterizing this formation, and quarried away years ago at Kellaways for road-stone, jut out in the Valley of the Churn, near Cirencester, and stand about in clusters in the Valley of the Ouse at Bedford like gigantic fungi. The plane of separation of the Upper Oxford and the Kellaways in Bedfordshire is formed by a shelly calcareous band in contact with a shelly cap to the concretionary stones. Where this plane is a broken one there is no development of concreted rock, and the lowest sediment of Upper Oxford clay is loamy, passing down into Kellaways sand. Above the calcareous band there is sometimes an indurated seam of sandy marl, breaking into conical forms; the product, apparently, of stalactitic infiltration. Pits are opened at the outcrop of the Kellaways (a persistent stratum in the Ouse Valley) and are carried down through the Lower Oxford (selenite clay), Cornbrash and Cornbrash clay to Great Oolite limestone, which is quarried for lime-burning; the 'lam earth,' the loamy portion of the Kellaways, being mixed in the mill with the Lower Oxford, which is dug for brickmaking. Excellent sections, showing the above series, are to be seen.

Observations on the extensions of the Fullers' Earth Works at Woburn Sands, with some description of the beds, are given, and the mining industry now springing up is commented on.

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VII.—The Mastodon and Mammoth in Ontario, Canada. By Prof. J. Hoyes Panton, M.A., F.G.S.

THE writer in this paper gives a complete description of the remains of a Mastodon discovered (1890) in a marl bed near Highgate in the Province of Ontario, Canada, and also the remains of a Mammoth found under similar conditions near Shelburne in the same Province (1889).

Both specimens were discovered by John Jelly, Esq., of Shelburne. The following measurements are given for comparison :—

| | Jumbo. | Newburg Mastodon.[1] | Highgate Mastodon. |
|---|---|---|---|
| Longest rib ... ... ... | 44 inches | ... 54¾ | ... 55½ |
| Humerus ... ... ... | 36 ,, | ... 39 | ... 40 |
| Radius ... ... ... ... | — ,, | ... 29 | ... 34 |
| Femur ... ... ... ... | 42 ,, | ... 39 | ... 47½ |
| Tibia ... ... ... ... | — ,, | ... 28 | ... 29 |
| Tusk ... ... ... ... | — ,, | ... 104 | ... 92 not complete. |
| Third spinous process | ... 15 ,, | ... 23½ | ... 23¾ |

The bones obtained of the Mammoth are not so numerous, the chief being thirty-one ribs, one 50 inches in length and 11 in circumference; several vertebræ, some 14½ inches across; a massive tusk 12$\frac{2}{3}$ feet with a portion broken off; and a tooth weighing 16¾ lbs. The writer also refers to remains of Proboscoidea found at other points in Ontario, viz. St. Catherine's Dunville, Goat Island, Niagara Falls, and Kimbal, near the western side of the Province.

## VIII.—The Cause of Monoclinal Flexure. By A. J. Jukes-Browne, F.G.S.

FOLDS of the ordinary arch and trough type are generally ascribed to the influence of lateral pressure; but it is not easy to see how a monoclinal flexure which appears in section as a flexure connecting two horizontal bars of strata can have been produced by direct lateral pressure exerted at the ends of the bars.

The author suggests that monoclinal flexuring is a structure impressed upon a horizontal series of uncompressed strata by the displacement of a subjacent mass of faulted and flexured rocks, the lateral compression of the deep-seated mass resulting in the vertical uplift of certain portions of the 'cover.' If a series of stratified rocks rests in a horizontal position on a mass of ancient rock, which has been compressed, indurated, flexured, and faulted before the deposition of the upper series, it is supposed that the lower series of rocks would give way under lateral pressure along the pre-existing faults, and that the blocks which lie between upward diverging faults would be forced to move upwards, carrying with them those tracts of the 'cover' which rest on them. It is evident that these tracts would be divided from those resting on blocks defined by downward diverging faults by faults or monoclinal flexures, the production of a fracture or a flexure depending partly on the thickness and pliability of the strata forming the cover, and partly on the amount of local uplift. It is conceivable that the displacement might take place partly by faulting and partly by flexuring, and that what was a fault near the plane of unconformity might pass upward into a flexure.

The writer desires criticism on the above suggestion, especially from those who will have a chance of seeing the grand monoclinal flexures of the Colorado region during the excursion of the approaching International Geological Congress.

[1] The Newburg Mastodon is one of the finest ever discovered in America. The bones are in a most excellent state of preservation, and sufficient have been obtained to enable the skeleton to be set up.

IX.—The Origin of Petroleum. By O. C. D. Ross.

IN the course of introductory remarks the author contends that, owing to the mystery surrounding the origin of petroleum, and to the paucity of indications where to seek for it, practical men in this country distrust the permanence of the supply, and hesitate to adopt it for many useful purposes; while the object of this paper is to suggest a way of resolving the mystery which is calculated to dissipate that distrust. The theories suggested by Reichenbach, Berthelot, Mendelejeff, Virlet, Verneuil, Peckham, and others, which are briefly described, make no attempt to account for the exceeding variety in its chemical composition, in its specific gravity, its boiling-points, etc., and are all founded on some hypothetical process which differs from any with which we are acquainted; but modern geologists are agreed that (as a rule) the records of the earth's history should be read in accordance with those laws of Nature which continue in force at the present day. *E.g.*, the decomposition of fish would not now produce paraffin oil; hence we can hardly believe it possible thousands, or millions, of years ago, so long as it can be shown that any of the ordinary processes of Nature are calculated to produce it. The chief characteristics of petroleum strata are enumerated as: I. The existence of adjoining beds of limestone, gypsum, etc.; II. Volcanic action in close proximity; III. The presence of salt water in the wells; IV. The great extent of the production of oil, indicating subterranean receptacles of vast dimensions.

I. The close and invariable proximity of limestone to the wells has been noticed by all writers, but they have been most impressed by its being 'fossiliferous,' or shell limestone, and have drawn the erroneous inference that the animal matter once contained in those shells originated petroleum, but no fish oil ever contained *paraffin*. On the other hand, the fossil shells are carbonate of lime, and, as such, capable of producing petroleum under circumstances such as many limestone beds have been subjected to. All limestone rocks were formed under water, and are mainly composed of calcareous shells, corals, encrinites, and foraminifera, the latter similar to the foraminifera of 'Atlantic ooze' and of English chalk beds. Everywhere, under the microscope, its organic origin is conspicuous. Limestone is the most widely diffused of all rocks, and contains 12 per cent. of carbon. Petroleum consists largely of carbon, and there is a far larger accumulation of carbon in the limestone rocks of the United Kingdom than in all the Coal-measures the world contains. A range of limestone rock 100 miles in length, by 10 miles in width, and 1000 yards in depth, would contain 743,000 million tons of carbon, or sufficient to provide carbon for 875,000 million tons of petroleum. Deposits of bituminous shale have also limestone close at hand; *e.g.* coral-rag underlies the Kimmeridge clay, which is more or less saturated throughout with petroleum, and it also underlies the famous Black-shale of Kentucky, which is extraordinarily rich in oil.

II. The evidence of volcanic action in close proximity to petroleum

strata is next dealt with, and extracts in proof thereof are given from several writers. In illustration of volcanic action on carbonate of lime, a sulphur mine in Spain, within a short distance of an extinct volcano (with which the author is well acquainted), is mentioned. That petroleum is not far off is indicated by a perpetual gas flame in a neighbouring chapel and other symptoms; and, these circumstances having attracted his attention, he observed that Dr. Christoph Bishop records in his writings that he had produced sulphur in his own laboratory by passing hot volcanic gases through chalk, which fact further led the author to remark that, in addition to sulphur, *ethylene*, and all its homologues ($C_nH_{2n}$), which are the oils predominating at Baku, would be produced by treating—

2, 3, 4, 5.....equiv. of limestone (carbonate of lime) with
2, 3, 4, 5.....equiv. of sulphurous acid ($SO^2$) and
4, 6, 8, 10.....equiv. of sulphuretted hydrogen ($H^2S$);

and that *marsh gas* and its homologues, which are the oils predominating in Pennsylvania, would be produced by treating—

1, 2, 3, 4, 5.....equiv. of carbonate of lime, with
1, 2, 3, 4, 5.....equiv. of sulphurous acid, and
3, 5, 7, 9, 11.....equiv. of sulphuretted hydrogen.

Thus, we find that

| | | | |
|---|---|---|---|
| Carbonate of lime | $2Ca^2CO^3$ | yield | $2(Ca^2SO^4.H^2O)$ (gypsum) |
| Sulphurous acid | $2SO^2$ | | 4S (sulphur) |
| and sulphuretted hydrogen | $4H^2S$ | | $C^2H^4$, which is *ethylene*, |

and

| | | | |
|---|---|---|---|
| Carbonate of lime | $Ca^2CO^3$ | yield | $Ca^2SO^4.H^2O$ (gypsum) |
| Sulphurous acid | $SO^2$ | | 3S (sulphur) |
| and sulphuretted hydrogen | $3H^2S$ | | $CH^4$, which is *marsh gas*. |

These and all their homologues would be produced in nature by the action of volcanic gases on limestone.

But much the most abundant of the volcanic gases appear (at any rate at the surface) as steam, and petroleum appears to have been more usually produced without sulphurous acid and with part of the sulphuretted hydrogen $H^2S$ replaced by $H^2O$ (steam), or $H^2O^2$ (peroxide of hydrogen), which is the product that results from the combination of sulphuretted hydrogen and sulphurous acid ($H^2S+SO^2=H^2O^2+2S$). Thus

| | | | |
|---|---|---|---|
| $Ca^2CO^3$ | yield | $Ca^2SO^4.H^2O$ (gypsum) | |
| $H^2S$ | | and | |
| $2H^2O$ | | $CH^4$, *marsh gas* | |

and

| | | | |
|---|---|---|---|
| $2Ca^2CO^3$ | yield | $2Ca^2SO^4.H^2O$ (gypsum) | |
| $2H^2S$ | | and | |
| $2H^2O^2$ | | $C^2H^4$, or *ethylene*. | |

Four tables are given at the end of the paper, showing the formulæ for the homologues of ethylene and marsh gas resulting from the increase in regular gradation of the same constituents.

It is explained that these effects must have occurred, not at periods of acute volcanic eruptions, but in conditions which may be and have been observed at the present time wherever there are active solfataras, or fumaroles, at work. Descriptions of the action of solfataras by the late Sir Richard Burton and a British Consul in

Iceland are quoted, also a paragraph from Lyell's "Principles of Geology," in which he says that the mud-volcanoes at Girgenti, in the Tertiary limestone formation, "are known to have been casting out water, mixed with mud and *bitumen*, with the same activity for the last fifteen centuries." Probably at all these solfataras, if the gases traverse limestone, fresh deposits of oil-bearing strata are accumulating; and how much may there not have been produced during fifteen centuries!

Gypsum may also be an indication of oil-bearing strata, for the substitution in limestone of sulphuric for carbonic acid can only be accounted for by the action of these sulphurous gases. The abundance of gypsum in the United Kingdom indicates that large volumes of petroleum are probably stored in places where it has never yet been sought for. Gypsum is found extensively in the petroleum districts of the United States, and it underlies the rock-salt beds of Middlesboro' (N.E. Yorkshire), where, on being pierced, it has given passage to oil-gas, which issues abundantly mixed with brine, and under great pressure from a great depth.

III. and IV.—Besides the space occupied by 'natural gas,' 17,000 million gallons of petroleum have been raised in America since 1860, and that quantity must have occupied 100,000,000 cubic yards; a space equel to a subterranean cavern 100 yards wide by twenty feet high and eighty-two miles in length, and it is suggested that beds of 'porous sandstone' could hardly find room for so much; while vast receptacles may exist, carved by water out of former beds of rock-salt adjoining the limestone.

This would account for the brine; and the increase to the molecular volume of the gases consequent thereon, would in part account for the pressure. It is further suggested that when no such open spaces were available, the hydro-carbon vapours were absorbed into and condensed in contiguous clays and shales, and perhaps also in beds of coal, only partially consolidated at the time. There is an extensive *bituminous limestone* formation in Persia, containing 20 per cent. of bitumen; and the theory elaborated in the paper would account for bitumen and oil having been found in Canada and Tennessee imbedded in limestone, which fact Mr. Peckham (in his article on Petroleum in the 'Encyclopædia Brit.,' 9th edition) thought was a corroboration of his belief that some petroleums are a "product of the decomposition of animal remains."

Above all, this theory accounts for the many varieties in the chemical composition of paraffin oils, in accordance with ordinary operations of Nature during successive geological periods.

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## X.—The Geology of Petroleum and Natural Gas. By W. Topley, F.R.S., Assoc. Inst. C.E.

THE object of this paper is to give a summary of some of the more important facts as to the geological conditions under which petroleum and natural gas are found in various parts of the world, noting the geological ages of the rocks in which they occur, and the influence of geological structure in determining this occurrence.

Few cases are known in which petroleum occurs in rocks older than the Silurian, and none where the amount is of any importance.

Petroleum occurs, but not in large quantity, in a trachyte-breccia at Taranaki, New Zealand. In N.W. Hungary it is found in a trachytic tuff of Miocene age. These, however, are exceptional cases; not only is petroleum not found in volcanic rocks, but in the great majority of cases it is far removed from any known indications of true volcanic action.

The great stores of petroleum and gas in Pennsylvania and New York are in sandstone beds of the Devonian and Lower Carboniferous rocks. Of late years great quantities of gas and oil have been obtained, chiefly in Ohio and Indiana, from the Trenton Limestone (Ordovician).

The oil- and gas-fields of Pennsylvania and New York have a very simple geological structure. The rocks lie comparatively undisturbed, being only gently folded into a series of anticlinals and synclinals parallel with, and along the N.W. side of, the main axes of the Alleghanies. These folds have themselves a gentle inclination towards the S.W. In the Alleghanies, and to the S.E. of the range, where the rocks are greatly disturbed, neither oil nor gas is found. Some of the larger gas wells are on or near the summits of anticlinals, but many are not so placed. In the Trenton Limestone fields of Ohio and Indiana the productive areas are mainly over anticlinals, gas occurring at the crown of the arch, oil on the slopes.

The essential conditions for a largely productive field of gas or oil are—a porous reservoir (generally sandstone or limestone) in which the hydrocarbons can be stored, and an impervious cover of shale retaining them in the reservoir. It is also believed that they only occur where, in or under the porous reservoir, there have been accumulations of fossil remains, the original decomposition of which yielded the hydrocarbons. In the case of the sandstones the original source was probably the fossiliferous shales which underlie them; in the case of the Trenton Limestone the source was probably the fossiliferous limestone itself. The limestone is only productive under certain circumstances; in its normal condition it is a compact rock, and then it contains neither gas nor oil. But over large areas the limestone has been dolomitized, and so transformed into a cavernous and porous rock in which gas and oil are stored. The enormous quantities of gas and oil given out from beds of limestone and sandstone can be fully accounted for when their porous nature, thickness, and extent are taken into consideration. Some of these rocks can contain from $\frac{1}{10}$th to $\frac{1}{5}$th of their bulk of oil.

The high pressure under which gas and oil flow from deep borings can in most cases be fully explained by artesian pressure.

In Kansas gas occurs mainly in the Lower Coal-measures. In Kentucky and Tennessee oil is found in the Ohio shales (Upper Devonian), in Colorado in shales of Cretaceous age. In California it is found in Tertiary strata, mostly much disturbed.

In Canada the chief source, in Ontario, is in Devonian rocks, along a well-marked anticlinal; but gas and oil also occur in the

Trenton Limestone. In the North-West Territories there seem to be great stores of oil in Devonian rocks. Gas and oil now found in Cretaceous strata of the prairies and Athabasca may have been derived from underlying Devonian rocks; but in the Rocky Mountains, at Crow's Nest Pass, oil is probably native to the Cretaceous beds.

In Mexico, the West Indies, and parts of South America, Tertiary strata seem to be the chief source of oil. The age of the petroleum-bearing unfossiliferous sands, etc., of the Argentine Republic (province of Jujuy) is not certainly known; they have been referred by different writers to various ages from Silurian to Tertiary; they are probably sub-Cretaceous. In Europe and Asia the petroleum-bearing beds are of Secondary or Tertiary age, the Palæozoic rocks yielding only an insignificant supply.

In North-west Germany we find petroleum in the Keuper Beds, and more or less in other strata up to and including the Gault. As we pass to the south and south-east from this district we find, as a general rule, that oil occurs in newer strata. The various productive horizons of different districts are as follows:—

| | |
|---|---|
| North-west Germany ... ... | Keuper to Gault. |
| Rhone Valley<br>Savoy } ... ... ... | Jurassic. |
| Pyrenees<br>Spain } ... ... ... | Neocomian and Cretaceous. |
| Elsass ... ... ... ... ... | Oligocene. |
| Bavaria ... ... ... ... ... | Lower Tertiary (Flysch). |
| Italy ... ... ... ... ... ... | Eocene. |
| Galicia<br>North-east Hungary } ... ... | Neocomian to Miocene. |
| Poland<br>Roumania<br>Caucasus } ... ... ... | Miocene. |

The important districts of Baku occur on plains over anticlinals of Miocene beds. The petroleum-bearing sands are interstratified with impervious clays, separating the strata into distinct productive horizons.

In Algeria oil occurs in Lower Tertiary beds. The Egyptian petroleum comes from Miocene strata.

Petroleum seems to be unknown in peninsular India; but it occurs in many places along the flanks of the Himalayan range, and also in Lower Burma, generally in Lower Tertiary strata. In Upper Burma and Japan the oil-bearing rocks are probably Newer Tertiary. In all these areas the beds are greatly disturbed, and the same is the case with the great Carpathian field; but it frequently happens that the most productive regions are along anticlinal lines.

In New Zealand oil occurs in Cretaceous and Tertiary strata.

Petroleum and gas almost universally occur associated with brine. This may come wholly or partly from the decomposition of the animal matter which has produced the hydrocarbons, together with the remains of the sea-water originally present in the rocks. But the frequent occurrence of rock-salt in the neighbourhood of petroleum-bearing districts is worthy of note.

*Summary.*—The main points to be considered in respect of the geological conditions under which petroleum and gas occur seem to be as follows:—

1. They occur in rocks of all geological ages, from Silurian upwards. The most productive areas are Palæozoic in North America, Miocene in the Caucasus.

2. There is no relation to volcanic action.

3. The most productive areas for oil in great quantity are where the strata are comparatively undisturbed. Oil, but in less abundance, frequently occurs when the strata are highly disturbed and contorted, but gas is rarely so found.

4. The main requisites for a productive oil- or gas-field are a porous reservoir (sandstone or limestone) and an impervious cover.

5. Both in comparatively undisturbed and in highly disturbed areas, an anticlinal structure often favours the accumulation of oil and gas in the domes of the arches.

6. Brine is an almost universal accompaniment of oil and gas.

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XI.—Vulcanicity in Lower Devonian Rocks. The Prawle Problem. By W. A. E. Ussher, F.G.S. [Communicated by permission of the Director-General of the Geological Survey.]

IN the area extending south from the Middle Devonian volcanic series of Ashprington to the Prawle there appears to be no proof of the occurrence of strata older than Lower Devonian. There is no adequate reason for assuming that Lower Devonian rocks as old as the Gedinnian occur on the surface, and there is no certainty that the lowest beds are older than the Lower Coblenzian.

The occurrence of local volcanic action in Lower Devonian time is proved by a series of diabases and tuffs near Dartmouth, in the Kingswear Promontory, near Stoke Fleming, and in the line of country west from Torcross.

In association with the northern chloritic band (running from the mouth of the valley on the north of Hull Sands on the east to Hope on the west) we find volcanic materials identical in character with varieties of volcanic rocks associated with the Devonian slates in the line of country west from Torcross; and here and there in the line of country west from Torcross the volcanic rocks assume a more or less pronounced chloritic aspect. The junction of the slates on the north with the northern chloritic band is a strictly normal one, the chloritic rocks being almost invariably separated from the slates by brown volcanic materials which are everywhere succeeded by the same type of Devonian slate, and in the Southpool Creek and many other sections are found to pass insensibly into the chloritic type. In the Southpool Creek section a hard bluish diabase (? aphanite) occurs in the chloritic band. In the southern chloritic districts of the Prawle the volcanic rocks may still be here and there detected by texture or colour. Volcanic rocks occur in the mica schists of the Start coast, and can be detected even when only a few inches in thickness. At Spirit-of-the-Ocean Cove chloritic rock with much felspar occurs in association with tuffs and a grey rock with

incipient foliation, presenting a slightly gneissoid appearance, and apparently a much sheared diabase. The association of the chloritic rocks with the mica schists is of as intimate a nature as that of the volcanic materials with the unaltered slates to the north. From these facts it seems evident that the chloritic series is nothing more than a Devonian volcanic group, of which the Torcross, Stoke Fleming, Dartmouth, and Kingswear coast tuffs and diabases were either sporadic offshoots or evidences of more or less contemporaneous local vulcanicity.

The more evident crinkling of the mica schists in contact with the chloritic group seems to be due to their comparative softness and greater fissility during the crumpling and contraction to which both were subjected.

The comparative suddenness of the transition from unaltered to more or less highly altered rocks may be explained by the lessening of strain (in receding from the harder masses of ancient rocks, against which the beds were jammed), being coincident with the thinning out of the volcanic materials northward, and furthermore favoured by the soft character of the grey slates with limonitic interfilmings which everywhere bound the northern chloritic band on the north. It is not the author's present purpose to enter more particularly into the stratigraphy of this interesting region, which is not yet thoroughly worked out. It only remains to acknowledge the prior claim of Mr. Somervail to the suggestion of the identity of the Devonian diabases with the chloritic rocks.[1]

## XII.—Note on Boulders at Darley, near Matlock, Derbyshire.

By Herbert Bolton.

DURING the excavation for a small lake close to the Midland Railway Station at Darley, near Matlock, a cluster of fifteen boulders were exposed, the size of several being sufficient to justify an examination. The boulders lay in a bed of Boulder-clay which had a thickness of nine feet.

The upper part of the clay was of a strong yellow colour and very stiff. Below, the colour varied from yellow to brown and red, and pockets of sand were common.

Only two boulders were rounded, the rest being sub-angular, on their upper half, and fairly angular on the lower.

All the boulders consist of gritstone identical in character with the Chatsworth grit of the adjoining hills.

No striations occur in the boulders, but this may be due to the original surface having crumbled away.

A series of parallel and shallow grooves occur on the side of the largest boulders, and a deep hollow has been scooped out of its southern face.

The major axis of the undisturbed boulder was approximately north and south, the general direction of the cluster being 8° west of north. The blocks were arranged in the order of their weight

[1] The views above expressed are those to which the author himself has been led, but they have not yet been fully considered and adopted by the Geological Survey.

a north to south direction. The clay was found to rest upon a posit of the nature of river gravel.

The writer is of opinion that the clay is redistributed Boulder-ay from the adjoining heights, and that the boulders were brought wn at the same time from the line of outcrop of the grit.

He is led to this conclusion by the local character of the boulders, e almost total absence of foreigners, and the character of the clay. The red and brown colour of the latter at its base seems to show at oxidation of the contained iron has proceeded for a longer time an in the case of the uppermost clay. This would be expected if e clay was redistributed, for the basement mass of clay must ve been the superficial clay of the heights. The enclosed sand ould also indicate the complete disintegration of boulders of grit-one, etc., whilst the clay was in its primary position.

The amount of disintegration which has taken place since redis-ibution is marked by the crumbling surface of the large boulders. The general direction of the boulders may be explained by noticing at the river flows from north to south.

## REVIEWS.

—Pineal Fontanelle of Placoderm and Catfish. By Bashford Dean, A.M., Ph.D. Nineteenth Report of the Commissioners of Fisheries of the State of New York, pp. 307–363, pls. i.–xiv. (Albany, 1891.)

DR. DEAN, as assistant to Prof. Newberry, of Columbia College, New York, has had the privilege of studying the fine skulls *Dinichthys* described by the Professor. He has directed attention ore especially to the pineal region of the cranial shield, and now tempts to show, from a study of the pineal foramen in the luroids, that the well-known foramen in *Dinichthys* and its allies ust have been the seat of a median eye. The aperture is remark-ly minute, and after a detailed description of the surrounding one, Dr. Dean remarks that this foramen "becomes naturally the nhole of the camera to produce an inverted image upon the retina, condition almost unparalleled for primitive simplicity, obviating it does a diaphragm (iris), as well as the specialized humours, ueous, crystalline, and vitreous. Moreover, it will at once be en to do away as well with all devices for accommodation, since e focal distance would be practically the same for a point at any ven distance." The author's numerous dissections of the soft rts of the Siluroid head afford material for a valuable series of tes and figures; and it seems to be demonstrated that the pineal e exists in a very degenerate condition. At the same time, we il to recognize in the new memoir any additional evidence in vour of the supposed genetic connexion between the Coccostean hes and modern Siluroids. Dr. Dean's researches merely result the plausible explanation of a feature in the cranial roof of *inichthys*, by reference to a nearly analogous structure in an isting type of fish.

A. S. W.

### II.—Cretaceous Fishes from Mexico.

IN a recent description of a series of Jurassic and Cretaceous fossils from Mexico (Palæontographica, vol. xxxvii. pp. 189–194, pl. xxviii. figs. 14–18, pl. xxix. fig. 3, pl. xxx. figs. 3–5, 8–10), Dr. J. Felix refers to some fish-remains from the Neocomian of Cerro de la Virgen, near Tlaxiaco. The new genus and species, *Otomitla speciosa*, is founded upon a skull and badly preserved trunk, apparently of a Lepidosteoid ganoid. The bones of the head and opercular apparatus are externally sculptured, and the dentition consists of very large conical teeth; the vertebræ are completely ossified, biconcave; and the scales are rhomboidal, much broader than deep on the ventral aspect. The imperfectly known *Neorhombolepis*, of the English Chalk, presents several striking features of resemblance. Associated with *Otomitla* it is interesting to find recognizable remains of a species of *Belonostomus*, described under the name of *B. ornatus*. The vertebræ in this fish are completely ossified, as in some other Cretaceous species.

Though limited to the description of two definable genera and species, Dr. Felix' contribution is of great interest as relating to a region that has not hitherto yielded fossil fishes. *Belonostomus* has now been found in the Cretaceous of Europe, India, Mexico, Brazil, and Queensland; and the geographical distribution of the genera of fishes of the Cretaceous period is gradually becoming a subject concerning which so many facts are known as almost to justify an attempt at broad generalizations. A. S. W.

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### III.—Winchester College Natural History Society. "Geological Notes." Fcap. 8vo. pp. 32. (Winchester, J. Wells, 1891.) Price 1*s*.

FOR many years the above Society has published in its Reports lists of the Fauna and Flora, both Recent and Fossil, of the neighbourhood of Winchester. The lists of Recent forms attained some years ago to such a degree of completeness, that their repeated issue seemed unnecessary. The list of Fossils, on the other hand, has been rendered, through new discoveries and new views, somewhat antiquated, and it is a happy thought of Mr. C. Griffith to issue it in a separate and more convenient form.

The present edition begins with a short description of the Chalk of Hampshire, its zones and its foldings. Then follows a list of Pits and Sections near Winchester; for each of these is given the zone and a complete list of fossils, while to most are added the dip and any other information of interest: twenty-five such localities in the Chalk, and six in the Eocene are thus recorded. The Chalk in the Winchester Anticlinal extends from the Senonian zone of *Belemnitella quadrata* down to the zone of *Holaster subglobosus* in the Cenomanian. From it 186 species, excluding Plants and Foraminifera, are here recorded. These are displayed in a Table, arranged according to the main zoological divisions, which shows the vertical distribution of each species through the zones. Thus, while the

irst list should be of much value to the local collector, the second ffords matter for thought to the stratigraphical geologist. Care ppears to have been taken in determining the species, and the ames are commendably up to date; it would appear that many ew forms need description.

The public spirit shown in the printing of these lists deserves upport at the hands of all interested in Cretaceous Geology. Since t must be some years before a fresh edition can be brought out, Ir. Griffith proposes to issue a supplementary sheet from time o time. F. A. B.

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V.—L'Evolution des Formes Animales avant l'Apparition de l'Homme. Par F. Priem. 8vo. pp. 384 and 175 Figures. Bibliothèque scientifique contemporaine. (J. B. Baillière et Fils, Paris, 1891.) 3 fr.

DID there exist a class of people perfectly familiar with the most technical terms of modern science, and deeply interested in its ost abstruse problems, yet at the same time absolutely ignorant of ll its conclusions, then we could understand the commercial value f books like the present. As for its educational worth, a book at compresses the history of "all the animal forms discovered in eological strata" into 363 small pages of large leaded type, and at enters therewith into such details as the description of the ines of a single species of *Cidaris*, may amuse the palæontologist, ut can hardly instruct the student.

We do not wish to be hard on Professor Priem; he has done his ack-work no worse than this sort of thing is usually done. While bstaining from rash speculation on his own account, he has given, s a rule, the views of the most recent writers, among whom he as naturally gleaned much from Neumayr, and to a commendable bsence of dogmatic statement he joins much fairness in stating the iews of those with whom he does not agree. For example, while ie history of the Cephalopoda is far sounder than that given in ost text-books, the views of Munier-Chalmas on *Spirula*, and einmann on *Argonauta*, though not accepted, are given considerable ome would say too much) prominence.

It is the easiest thing in the world to pick holes in patch-work, ut the occupation is somewhat unprofitable. Here, however, are few weak places for the author's consideration. *Globigerina* ooze not found at a greater depth than 4000 mètres, because, suggests . Priem, the high pressure of the water breaks these fragile ells. The tentacles of Echinoderms are *not* called "ambulacra." he Echinoderm skin is hardly "incrustrée [*sic*] de calcaire." he "dorsocentral" of a crinoid is *not* the same as either the entrodorsal" or the mythical "orocentral." The larva of *Antedon* sembles many genera rather than *Pentacrinus*. If the Neritidæ e descended from the Trochidæ, how does M. Priem explain the tal difference in their radulæ? *Helix* owns a more remote tiquity than the Lower Eocene; it has been found in the Gault.

And what on earth induced the author to pen this sentence: "Le nombre des chambres chez les *Orthoceras* est invariable"?

The publishers have secured numerous illustrations, the better ones being reprinted from Professor Gaudry's "Enchaînements du Monde Animal," recently reviewed in these pages. But we regret to see once more the caricature of *Ichthyocrinus piriformis*, that, under the name of "*Cyathocrinus pyriformis*," disgraces p. 89. No *Trigonia* ever had lines of growth like those drawn in fig. 82; the engraver cannot have seen the shell. Fig. 106, a worse copy of a bad original (Pictet 'Traité de Paléont.' pl. liii. fig. 6) hardly represents the typical form of *Amaltheus margaritatus*. The drawings of *Coccosteus*, *Pterodactylus*, and *Megatherium* are more than old, they are senile; it is to be hoped that their errors will soon pass to the land where all things are forgotten.

The printer seems to have placed the blocks at his own sweet will; some Gasteropod and Cephalopod shells are placed with the mouth upwards, others with it downwards, while even a skull of *Teleosaurus* (fig. 149) is topsy-turvy. And here is a little sum for him: if every volume of the 'Bibliothèque scientifique contemporaine' has as many misprints as the present one, how many thousands do they amount to? F. A. B.

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V.—Transactions of the Leeds Geological Association. Part VI. 1890–91. Edited by W. Lower Carter, M.A., F.G.S. (Leeds, 1891.)

As indicated by the new part of its Transactions just received, the Leeds Geological Association still continues to maintain its position as one of the most flourishing of provincial societies. While specially concerned with the facts of Yorkshire Geology, and devoting much time to field-excursions, the Association also encourages the discussion of wider subjects of general interest; and useful abstracts of all the communications are comprised in the first half of the Report. The Presidential Address (by Mr. C. Brownridge, F.G.S.) relates to the building and paving stones employed in Leeds. Other contributions to local geology are entitled "A Geological Tour through Durham into Cumberland" (by Mr. W. Cheetham), "A Long-buried Oak" (by Mr. B. Holgate, F.G.S.), "A Geological Episode as recorded in the Ingleton Granite" (by Mr. T. Tate, F.G.S.), and "From Kettleness to Saltburn" (by Mr. E. Hawkesworth). Among more general papers, Prof. A. Lupton discusses "A Gold Mine, a Slate Mine, and a Salt Mine," while Mr. J. E. Marr has some brief remarks on "The Backbone of England." Other readable summaries of special geological subjects are also given; and the latter half of the Report is devoted to a well-written account of the Field Excursions, which will prove of much value to all geologists who wish to study the district. The Membership of the Association is well maintained, and the latest additions to the list of Honorary Members are the names of Messrs. J. E. Marr and A. Smith Woodward.

### VI.—The Ancestral Horse.

Notice sur *l'Hipparion crassum* de Rousillon. By Marie Pavlow. Bull. Soc. Imp. Nat. Moscou, 1891.

Qu'est ce que c'est que *l'Hipparion*. By Marie Pavlow. *Ibid.*

In these brief notes Madame Pavlow re-states her views as to the specialized character of *Hipparion*, and the impossibility of its being an ancestral form of *Equus*. She regards the lower dentition ascribed to *H. crassum* by Depéret as erroneously determined, preferring to assign it to *Equus*; and the supposed limbs of the Indian *H. antilopinum* seem to her to be more probably referable to *Equus stenonis*.

## REPORTS AND PROCEEDINGS.

### I.—Address to the Geological Section of the British Association, by Professor T. Rupert Jones, F.R.S., F.G.S., President of the Section, Cardiff, August 21st, 1891.

1. *Introduction.*—The *black stones that burn* probably came to be known by pre-historic people through accident, here and there, long before any notion of their worth to the community at large was entertained. Wood at first, and then charcoal, supplied fuel far into historic times, on every hand, except perhaps in China. In the first century of the Christian era the Romans, occupying England, met with coal, and probably learnt its use from the natives. It seems, however, to have been disregarded during the Saxon conquest and domination of this Island; but by the beginning of the twelfth century the use of coal was well in hand again, as shown by old charters relating to places in Scotland and the county of Durham.

The history of the use of coal is treated of in the following books:—'The Coal-fields of Great Britain: their History, Structure, and Resources, with notices of the Coal-fields of other parts of the World.' By Edward Hull, M.A., etc., with maps and illustrations. 8vo. London. First edition, 1861; second, 1861; third, 1873; fourth, 1881. 'Coal: its History and Uses.' By Professors Green, Miall, Thorpe, Rücker, and Marshall. Edited by Professor Thorpe. 8vo. London, 1878. Also in the unpretentious pamphlet, 'The History of Coal.' By the Rev. Thomas Wiltshire, M.A., etc. 8vo. London, 1878. Of course the most comprehensive work on the British Coal-measures is the 'Report of the Commissioners appointed to Inquire into the several matters relating to Coal in the United Kingdom,' 3 vols., with maps and sections. Fol. London, 1871. Other valuable works are: W. W. Smyth's 'Coal and Coal Mining,' 8vo. 1867, and later editions; and Richard Meade's 'Coal and Iron Industries of the United Kingdom,' etc. 8vo. London, 1882. 'Coal: its Geological and Geographical Position.' By Professor John Morris, 8vo. London, 1862, although only a pamphlet, is valuable for its information.

The subject of Coal and the Coal-measures is abundantly treated of in the scientific literature of this century in nearly all parts of the world, and it would be useless to endeavour to do justice to its bibliography. Besides having had the advantage of the labours of the many eminent foreign geologists who have advanced our knowledge of the subject in one or other of its various aspects, both by original research[1] and by condensing

[1] Especially Sternberg, Brongniart, Goeppert, Petzholdt, Geinitz, Unger, Schimper, Weiss, Renault, and Grand Eury.

published results in treatises and manuals for students,[1] we have had some of the most enthusiastic students of the natural history of the Carboniferous strata and fossils in our own country and within our own times. Their names must frequently occur in speaking of coal and its belongings.

The text-books and manuals of geology by De la Beche, Phillips, Trimmer, Lyell, Ansted, Jukes, Geikie, Prestwich, Green, Etheridge, and others, are safe guides: the Memoirs of the Geological Surveys of England and Wales, Scotland, Ireland, and India are mines of scientific wealth as regards the same matter; our palæobotanists Lindley, Hutton, Artis, Witham, Morris, Hooker, Binney, Bunbury, Dawes, Williamson, Carruthers, Balfour, Kidston, etc., have given us good results; and others, not specialists, have written good matter for our consideration. Abroad, among our American friends, we have, or have had, several of the State geologists (Emmons, Lesquereux, Rogers, Lesley, Newberry, Dana), who have studied the Coal-measures with care, besides Steinhauer, Brown, and others; but no one has so earnestly and successfully given his serious attention to this branch of geology and palæontology as Sir J. W. Dawson, of Montreal, not long since President of the British Association when we met at Birmingham in 1886. His numerous memoirs and elaborate work on 'Acadian Geology' supply abundant facts and sound theories in elucidation of the history of the Coal Period. Sir W. E. Logan, who indeed by his studies in South Wales was the first to give geologists a clue to the interpretation of much that was very obscure about coal, worked with Sir J. W. Dawson in the Nova-Scotian coal-field; and so also did Sir Charles Lyell, who there and elsewhere devoted much energy and acumen to the elucidation of the origin and formation of coal.

The indexes of successive volumes of the 'Geological Record' show how abundant have been papers and books on Coal, Coal-mines, Coal-fields, Carboniferous fossils, and correlative studies, within the last few years, abroad and at home. The subject is so extensive that we must confine ourselves to the coal of South Wales.

2. *The Coal-field of South Wales, as studied by Logan, De la Beche, and others.*—Had it been that the stone axe found in Monmouthshire by Edward Lloyd[2] were really associated with the outcrop of the coal there, and if truly belonging to the Stone age and used in hewing coal, as Professor Hull's mention of it seems to imply,[3] it would, indeed, have been one among the few known evidences of prehistoric coal-mining, and would tend to show that South Wales was among the places first made to yield this useful mineral.

At the present day South Wales and Monmouthshire yield coal in greater quantity and of more value (by over a million pounds sterling a year) than the coal-fields of Northumberland and Durham, or of Yorkshire and Derbyshire; and considerably more (by nearly £5,000,000) than that of the Clyde Basin and associated coal-fields of Scotland. Indeed, the annual value of the coal produced in South Wales with Monmouthshire may be said to be about eleven millions out of the whole forty-five millions sterling estimated as the value of the coal at the pit's mouth throughout the United Kingdom.

The great coal-field of South Wales has the especial credit of having supplied some of the earliest and most important facts and phenomena illustrative of the geological succession of the materials of the Coal-

[1] Omalius d'Halloy, Leonhard and Hoernes, Vogt, C. D'Orbigny and Gente, Beudant, Credner, Lapparent, Contjean, and others.

[2] 'In a steep rock called Craig y park, and others in the Parish of Istrayd Dyvodog, we observed divers veins of coal, exposed to sight as naked as the rock; and found a flint axe, somewhat like those used by the Americans' (*Phil. Trans.* vol. xxviii. 1714, p. 501; in a letter dated September 22, 1697).

[3] The Coal-fields, etc., 4th edit. p. 12.

measures, and of the natural history of the coal itself. To the perservering energy and accurate observation of Sir William E. Logan and Sir Henry T. De la Beche South Wales gave up the secrets of coal-growth, strengthening some earlier suppositions, correcting others, and establishing a firm basis for the theory that the coal has, for by far the most part, been formed of plants growing where the coal now lies, although some local varieties have arisen from the occasional driftage of floating timber and herbage, and of long-continued maceration of vegetable matter in lakes and pools elsewhere.

Mr. (afterwards Sir) W. E. Logan, having for several years worked on the geology of South Wales, in 1837 gave his maps and information to the enthusiastic promoter of the Geological Survey of the British Islands, Mr. (afterwards Sir) H. T. De la Beche, for public use in the construction of the Survey Map and in developing the structure of the country. The first volume of the "Memoirs of the Geological Survey," 1846, contains at p. 145, Sir H. T. De la Beche's acknowledgment of Sir (then Mr.) W. E. Logan's gift of the valuable results of his investigations in the Coal-measures and discovery of the nature and meaning of the frequent underclays, an account of which Mr. Logan had already published in the "Annual Report of the Royal Institution of South Wales" for 1839; in the "Proceedings of the Geological Society of London," vol. iii. February, 1840, p. 276, and March, 1842, p. 707, etc., and "Transactions of the Geological Society," second series, vol. vi. 1842, p. 491, etc.

The hypotheses of the formation of coal offered by earlier writers are carefully reviewed in De la Beche's elaborate memoir; and the growth of opinion as to coal having been made by plants growing in place is traced from De Luc (1793), Lindley and Hutton (1833 and 1835), Adolphe Brongniart (1838), to W. E. Logan, by whom, indeed, it was fully established before 1837. Opinions as to the nature of the *Stigmaria ficoides*, so abundant in the 'underclays,' are also referred to; and that it is really the root of *Sigillaria* is accepted on the good authority of Brongniart and Binney (p. 150). Dr. Buckland's summary (in his Anniversary Addresses to the Geological Society 1840 and 1841)[1] of what had been advanced by British geologists in the elucidation of the Coal-measures and their natural history comprised mainly the observations made by Ansted, Hawkshaw, Barber, Beaumont, J. E. Bowman, and particularly W. E. Logan. He stated in his Address of 1840 that "some of the vegetables which formed our beds of coal grew on the identical banks of sand and silt and mud which, being now indurated to stone and shale, form the strata that accompany the coal; whilst other portions of these plants have been drifted to various distances from the swamps, savannahs, and forests that gave them birth, particularly those that are dispersed through the sandstones, or mixed with fishes in the shale beds."

Dr. Buckland's summary in 1841 is given by De la Beche[2] "as expressing his opinion that the *Stigmaria ficoides* [which was at that time still regarded by many as an individual floating plant], growing in ponds or lagoons in the localities where we now discover its remains, by mixture with mud or silts disseminated among them, formed the underbeds, upon which also grew the plants which now form the coal-beds, these latter, by subsidence being covered by sand or mud, forming sandstone or shale, between the coal strata, successive coal-beds being formed as the necessary conditions arose." Sir (then Mr.) C. Lyell's important additions to the subject, then lately given in his "Travels in North America," two vols., 1845, quoted and applied by De la Beche, were subsequently enlarged in his "Second Visit," etc., two vols., 1849, and in his "Elements of Geology," edition 1851, and subsequently.

[1] Proceed. Geol. Soc. vol. iii. pp. 229 and 487.

[2] Mem. Geol. Survey, vol. i. 1846, p. 152.

De la Beche's Memoir, after having presented some explanation of geological phenomena, and treated of the general range and occurrence of the Silurian and Devonian rocks in the southern moiety of Wales and the South-western Counties of England, proceeds to describe the Carboniferous strata, and at p. 143 takes up the Coal-measures; and his work remains a classic authority on the subject. De la Beche's account of these strata has not been much modified, except by the descriptions of many additional fossils, and details about the special characters of those then known.

Other information, however, on the past and present conditions of the South-West Coal-field is found in Mr. (now Sir) A. C. Ramsay's paper "On the Denudation of South Wales and the adjacent English Counties," in the same volume of the "Memoirs of the Geological Survey"; and very much has been added by local observers, as shown by numerous papers on this coal-field and its constituents in the Reports, Proceedings, and Transactions of the Scientific Societies of South Wales.

3. *Origin of Coal.*—Coal is now generally accepted as being a compressed and chemically altered mass of ancient vegetables. The tissue of some of the trees and other plants may be detected in the substance more or less distinctly by fracture, by burning, and in thin sections. In some cases trees occur rooted in the attitude of growth, their stems rising upwards and their roots remaining in or below the coal. The accumulation of coal as seams of varying thicknesses, in very numerous parallel beds, can be explained by the gradual and long-continued subsidences of long and wide tracts of old marginal sea-beds, estuaries, and lagoons, with adjoining lands,[1] all more or less invested with vegetation. At the same time limited, isolated, and lenticular patches and nests of pure coal, usually in sandstone, have been probably due to floating masses of vegetation, matted plants and trees, becoming waterlogged and sinking in estuaries and shallow seas.

Some highly bituminous coal, like cannel and torbanite, may have been due to limited accumulations of macerated plants rotting in water; or to the bursting of those natural reservoirs, like peat-bogs, and a local arrangement of the resulting flow of Carbonaceous mud.

Mr. W. Galloway, in his memoir "On the Mode of Occurrence of Coal,"[2] carefully places before his readers the two sets of opinions about the origin and formation of coal. First, as to the place of growth and of carbonization being on the same ground, following De la Beche's statements and conclusions; and, secondly, as to the accumulation of vegetable matter, some dead and broken, some already decomposed, derived from the forests and herbage of marshy lands, and deposited in great lakes (as expressed by C. Grand'Eury in the "Annales des Mines," 1882), with the *Stigmariæ* living and dying as water-plants (as they were at first regarded, and thought to have been formed of a central body and long-spreading arms and leaves); while tall trees grew here and there on the water-side, until, falling down, they lay prostrate in the black mud; or, breaking off, left their rotting stumps still standing upright.

Mr. Galloway accepts the latter opinion to some extent, because he finds the roots in underclays to have no direct communication with the coals above them,—on account of the presence of persistent shaly layers, or, 'partings,' traversing coal-beds, and very intimately passing into the coaly matter itself,—on account of a seam being cannel-coal, blackband-ironstone, and shale in different parts of its extent, with a coal lying on it without an intervening underclay; and if this shows that a coal can have been formed without an underclay, he argues that any underclay need not have

[1] The Coalfields of Great Britain, 4th edit. p. 81, etc.

[2] Report and Transactions of the Cardiff Naturalists' Society, vol. xvii. (for 1885), 1886, pp. 20–34.

been necessarily the soil of a coal-seam. He acknowledges the subject to be one of difficulty ; and it seems to me that some at least, if not all, of the difficulties have been already removed by De la Beche, Lesley, Lyell, Dawson, and other observers.

4. *Area of the Coal-growth.*—For knowledge of what ruled the local occurrence of coal, we owe a great debt to Mr. R. A. C. Godwin-Austen, who had studied the geology of the South-western Counties with De la Beche. To him we are indebted for the approximate demarcation of the bounds and margins of the Carboniferous Formations, particularly for the probable land-limits and outward extension of the Coal-measures. In his valuable memoir "On the possible Extension of the Coal-measures,"[1] he explained the reasons for his indicating on the map then communicated to the Geological Society the physical configuration of North-western Europe at the close of the Palæozoic period, and the outline of the surfaces which supported the coal-vegetation. He concluded to define the place and range of this old coal-growth of what is now Western Europe as—

"An internal sea, around and occasionally over large parts of which the peculiar vegetation of the time was developed and entombed as the area rose and sank. A region with a central depressed area, such as Australia is supposed to present, and going down, by means of a long series of oscillations, would ultimately present just such an assemblage of deposits as our own Carboniferous group" (p. 73).

A further reference to this kind of level or hollow region is as follows:—

"The large level tracts which lie west of the Blue Mountains in Australia, into which the Lachlan, the Darling, and the Murrumbidgee, discharge." (Godwin-Austen's Lecture, Royal Institution of Great Britain, April 16, 1858.)

Such an area had also been indicated in Sir H. De la Beche's note to p. 296 of his memoir above mentioned, where he refers to 'the great area extending from the country drained by the Volga, eastward through eighty degrees of longitude into China, and from which the waters find no course outwards to the main ocean or to the seas connected with it.' With a gradual depression—with the detritus swept in by the rivers—and with a suitable flora and climate, there might here be both accumulations of vegetable matter grown in place, as well as limited deposits of drifted plants, under different conditions. De la Beche moreover, referred (p. 146) to the long flat coast of the eastern seaboard of South America, with its great rivers and abundant flora, as being analogous to some parts, at least, of the areas on which the coal-seams were formed.

The area of coal-growth in this North-west European region is represented on Mr. R. A. C. Godwin-Austen's map[2] as a littoral belt (varying in width as now exposed at the surface), reaching, in an approximately semicircular or bay-like shape, from the Elbe near Magdeburg, and north of the Hartz, westward to the valley of the Ruhr, including a southern extension to Marburg ; and, taken up again, it passes from Ruhr to Aix-la-Chapelle, and to Namur and Charleroi ; then by the Franco-Belgian coal-field to Calais, and beneath the valley of the Thames to Bristol, Forest of Dean, and South Wales, south of the Old Red area, towards Ireland. On the eastern side of Hereford, and along the east border of the old rocks of Wales, the range of the coal-growth is shown by the coals appearing here and there along the Severn and the Dee ; and doubtless it widened out considerably eastward across what is now England. Continuing northward it occupied Northumbria, and stretched westward locally between the old Cumbrian land and the South Highlands ; passing around the east end of the latter, it was strong across what is now Central

[1] Quart. Journ. Geol. Soc., vol. xii. 1856, pp. 38–73; also Report Coal Commission, 1871, pp. 424 and 511, with plates; and Rep. Brit. Assoc. for 1879, p. 227, pl. xiv.

[2] Pl. i. Q.J.G.S., vol. xii. 1856.

Scotland, with indications in North Ireland. Thus the coal-growth invested the southern and western edges of Godwin-Austen's 'internal sea' above-mentioned, and extended westward by two outlets: one at its south-west corner, by South Wales; and the other on the north-west, by Central Scotland, each into the Irish area, and thus roughly surrounding the several older Palæozoic lands of Wales, Ireland, Cumbria, and South Scotland.

In Professor Ramsay's account of the denuded remnants of the Welsh coal-fields [1] the stretch of coal-growth along the border of the old Cambrian land is clearly indicated in his statement, that—

"One denuded edge of these accumulations now forms part of the counties of Pembroke, Caermarthen, Glamorgan, and Monmouth, and is elsewhere exhibited in the Forest of Dean, the narrow strips of Coal-measures north of May Hill in Gloucestershire, the Clee Hills (outliers of the Forest of Wyre and Coalbrookdale), the coal-fields south and west of Shrewsbury, and that of Oswestry, Wrexham, and Mold. All these are but fragments of one great original coal-field, once mantling round North Wales and the older rocks west of the Severn and north of Bristol Channel."

Both north and south, however, of the old Cumbrian area are a few seemingly isolated patches of coal; but the Whitehaven field is really the western portion of the North-of-England coal-growth; the coal of Anglesea belongs to the westward extension of the Lancashire field; and that of Ingleton is a remnant of the northern part of the latter towards the margin of the old Cumbrian land.

5. *Coal-field of South Wales: its extent, thickness, and constituent strata.*—The valuable coal-field of South Wales (estimated by some to occupy 640,000 acres, and stated by others to be 906 square miles in extent) forms an irregular oval basin or trough lying E. and W. (about fifty-six miles long, from Pontypool to Caermarthen Bay), with a narrow extension westward beyond Caermarthen Bay, through Pembrokeshire to St. Bride's Bay (about seventeen miles long). The greatest width is about sixteen miles. In 1881 there were 662 collieries at work (see Hull, 1881). The strata of the whole area have been much undulated and broken; on the south they dip at an angle of 45°, and at about 12° on the north. Great faults, approximately north and south, alter the levels from forty to a hundred fathoms; they are generally filled with clay; but one, near Swansea, many fathoms wide, is filled with fragments of the broken strata (Trimmer).

A strong *anticline* once passed along the middle of the trough (E. and W.), with its complemental *synclines*, one on each side. These have been somewhat shifted (the eastern moiety towards the S.W., and the other to the N.E.) by a great oblique *fault* coincident with the valley of the Neath. Except at Swansea and Caermarthen Bays, the outcrops of the lowest part of the series of strata, of irregular width, are continuous around the coal-field. About seven unequal patches of the upper measures have been preserved from denudation in the *synclines*. Two of these areas are in the eastern moiety; both long, but the southern syncline retains only a narrow and interrupted series of patches.[2] The Ebbw, the Sirhowy, the Rhymney, and the upper part of the Afon cross the former; the Taff and the Rhondda, with their branches, cross both synclines; and the Ely and Ogwa cross the lower syncline. The respective valleys give local opportunities for opening certain beds, and afford facilities for roads and railways from the hills to the sea-coast. In the western moiety there are five circumscribed areas of the upper measures in the two synclines; the united Amman and Llwchwr River runs between four of them, and the Tawe

[1] Mem. Geol. Surv. vol. i. 1846, p. 314.

[2] See Hull's 'The Coalfields,' etc., 4th edition, pp. 88, etc., and map.

between two and across one (just north of Swansea). The favourable position for mining some of the measures is due to the local angle of dip in the synclinal strata; and, indeed, without the anticlinal arrangement some of the coals could never have been reached even by deep mines.[1]

Mr. Etheridge (in his new edition of Phillips's "Manual of Geology," 1885, p. 238) mentions that in the southern part of the western moiety the Coal-measures have a thickness of 11,000 feet; and that on the northern side of the anticlinal axis there they are 7000 feet thick, and that near Britton Ferry, in the middle, they diminish to 4800 feet on that side.

Taking the whole basin or trough, it may be roundly said that in the north-east side the coals are mainly *coking* or *partly bituminous;* to the west and north-west they are *anthracitic;* and in the south *bituminous* or *gaseous;* and more especially that "in the Aberdare area the coals are very free-burning, but at the same time smokeless; hence their importance for steam purposes, especially the Aberdare four-foot steam-coal."[2]

The physical features and structural condition of the South-Welsh coal-field, also the occurrence of fossils, were succinctly treated of by G. P. Bevan in the "Geologist," vol. iii. 1860, pp. 90–99.

The order and thickness of the strata belonging to the coal-field of South Wales as given in Geikie's "Textbook of Geology," 2nd edit., 1885, p. 742, are (for Glamorganshire):—

| | |
|---|---|
| Upper series: sandstones, shales, etc., with 26 coal-seams, more than | 3400 feet. |
| Pennant grit: hard, thick-bedded sandstones, and 15 coal-seams ... | 3246 ,, |
| Lower series: shales, ironstones, and 34 coal-seams ... ... | 450 to 850 ,, |
| Millstone grit. | |

The Coal-measures are thus estimated at 7496 feet, or nearly 1½ mile in thickness, besides the Millstone-grit and the Carboniferous or Mountain Limestone occupying a still lower position.

Differences of observation or of opinion from time to time have caused different estimates. In 1855 Professor J. Phillips, who took a very strong interest in the geology of the coal-fields, published the following measurements (in his "Manual of Geology," 1855, p. 201) as representing only a general view, and he indicated that nearly 12,000 feet thickness may occur near Llanelly:—

| | |
|---|---|
| Llanelly series, with several beds of coal ... ... ... ... ... ... | 1000 feet. |
| Penllergare series of shales, sandstone and beds of coal—110 beds; 26 beds of coal ... .. ... ... ... ... ... .. .. ... ... | 3000 ,, |
| Central series (Townhill sandstones of Swansea = Pennant-grit of the Bristol coalfield)—62 beds; 16 beds of coal ... ... .. ... | 3246 ,, |
| Lower shales, coals, and ironstones (Merthyr)—266 beds; 34 beds of coal ... ... ... ... ... ... ... ... ... ... ... ... ... | 812 ,, |
| | 8058 |

Farewell Rock and Gower Shales, above the Carboniferous Limestone.

Professor Hull[3] gives about 1200 to the Coal-measures, with twenty-five seams of coal of two feet thickness and upwards; making a total of eighty-four feet of workable coal. In 1881 Professor Hull calculated that there remained about 32,166 millions of tons of available coal, which might possibly last for more than 1000 years at the present rate of consumption.

Mr. E. Rogers, in the "Memoirs of the Geol. Survey: Iron-Ores," part iii. 1861, p. 169, divides the Coal-measures of South Wales into an Upper and a Lower series, with the hard siliceous sandstone (locally a conglomerate), known as 'Cockshute' and 'White Rocks' between them. The upper measures, he says, are mostly micaceous sandstones, locally known as

[1] *Ibid*, chap. i.
[2] Etheridge, 1885. p. 238.
[3] "The Coalfields," etc., 1881, p. 108.

'Pennant Rocks.' The lower series is sometimes termed the 'iron-bearing measures,' as it contains the bulk of the ironstone as well as coal, which is bituminous on the east and gradually less and less bituminous westward, until after passing the great dyke or fault in the Vale of Neath it becomes anthracite. The upper series contains few iron-ores, and the coal is bituminous, even when anthracite exists below it, as in the Swansea district and elsewhere.

In his communication to the British Association in 1837,[1] Sir W. E. Logan stated that "the non-bituminous coal, or stone-coal, is found on the north side and at the west end; the bituminous coal on the south side and east end; and that there is an intermediate region occupied by an intermediate quality." These conditions of the coal-seams indicated to Logan "the possibility of a rule in the change of quality—namely, that it occurs in parallel planes, cutting the seams of coal without regard to their strike or inclination, and dipping to the south or east of south."

These coals begin to became anthracitic at Rhymney; and the change becomes gradually more and more marked as we pass by Dowlais, Cyfartha, Hirwain, Onlwyn, and Neath Valley, to the Swansea Valley,[2] according to analysis given by Mr. David Mushet in the Appendix to his "Papers on Iron and Steel," 8vo. London, 1840. At page 68 of this book Mr. Mushet notes that "in South Wales as the coals approach the anthracite district they are found to contain 90 per cent. (of carbon), with no more flame than is necessary to convert the coal into coke."

Mr. Etheridge (1885) accepts (p. 238) Professor Phillips's foregoing table; but he also arranges the coal-bearing portions as divisible into—1. Upper Pennant series; 2. Lower Pennant series; 3. White-ash series; and gives the following plan in addition :—

| | |
|---|---|
| 1. Upper or Penllergare series, more than | 3400 feet. |
| 2. Pennant-grit (Swansea) ... ... ... | 3246 ,, |
| 3. Lower Coal-measures ... ... ... | 450 to 850 ,, |

At p. 219 he reviews the whole of the series as—

| | |
|---|---|
| Coal-measures ... ... ... ... ... ... | 11,000 feet. |
| Millstone-grit ('Farewell Rock') ... ... | 300 ,, |
| Yoredale Rocks ('Gower Shale') ... ... | 1,600? ,, |
| Scar Limestone ... ... ... ... ... ... | 1,900 ,, |
| Lower Limestone Shales ... ... ... ... | 400 ,, |
| | 15,200 |

making the Coal-measures more than 1½ mile thick, and the whole series more than 2½ miles.

(*To be continued in our next Number.*)

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II.—Report of the Committee, consisting of Dr. John Evans (Chairman), Mr. B. Harrison (Secretary), and Professors J. Prestwich and H. G. Seeley, appointed to carry on excavations at Oldbury Hill, near Ightham, in order to ascertain the existence or otherwise of Rock-shelters at this spot. Drawn up by Mr. B. Harrison.

OWING to hindrances, the work could not be begun until August, 1890. The first excavation, immediately below the exposed rocks, was unproductive in a great measure. This was owing to huge trees being close by, the roots of which, forming a perfect network, offered serious obstacles, as, though permission had been

[1] "Report," 1838, Trans. Sec. p. 85.
[2] Bevan, "Geologist," vol. ii. 1859, pp. 78, 79.

granted by the owner to excavate, yet damage to the trees was strictly forbidden.

A section was first cut parallel with the face of the rock, but no true floor was reached, the rock itself being too near the surface, and forming merely a shoulder under the surface soil.

Many days at this being unsuccessful, another excavation was made on the slope of the hill just below, and a considerable area was trenched to a depth of about 3 feet.

Here, however, only Neolithic flakes were found; and great blocks, fallen from above, and deeply embedded in the soil, presented obstacles not easy to surmount. Later on work was commenced lower down still, at a spot where, in cultivating the ground in former years, relics of Palæolithic age had been found.

Two implements were secured, but the rocky conditions tried my labourers' strength; and to do the work thoroughly horse-power was needed, the blocks in many instances weighing more than half a ton. A good large area, however, was here trenched to a depth varying from 3 to 5 feet.

The slope of the bold projecting spur below Mount Pleasant, lying about fifty yards south-east of the former digging, was next tried, and here success crowned our efforts, for very soon immense numbers of flakes were met with, and in such profusion that I was prompted to carry on the work thoroughly.

Leave was asked for and granted for an area of some 9 or 10 rods to be worked over, and ere long finely fashioned characteristic Palæolithic implements were found daily, as well as flakes, some of these so minute that it seemed as if the actual workshop had been lighted on. Altogether 49 well-finished implements, or portions of them, and 648 waste flakes, have been found at this spot, leading to the supposition either that this was the frontage of a rock-shelter, or that the material had slipped down from above. We think that it would be highly desirable to make further excavations in this and the adjacent area.

The great portion of these flakes were found at depths varying from $2\frac{1}{2}$ to 3 feet; and, as a rule, they lay at the base, and immediately overlying a gravelly wash. The implements are very similar to some of those found in the rock-shelters of Central France.

Similar conditions to those of this spur appear on the north-west side of Oldbury Hill, near to an outcrop of rock; and at various times implements have been found near by.

Leave has been granted for work to be carried on here.

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III.—Report of the Committee, consisting of Mr. J. W. Davis (Chairman), Rev. E. Jones (Secretary), Drs. J. Evans and J. G. Garson, and Messrs. W. Pengelly, R. H. Tiddeman, and J. J. Wilkinson, to complete the Investigation of the Cave at Elbolton, near Skipton, in order to ascertain whether Remains of Palæolithic Man occur in the Lower Cave Earth.

THE Elbolton Cave Exploration was continued under the direction of your Committee until the end of December, 1890. The

entrance to the cave is through a shaft or pot-hole 20 feet in depth situated at the foot of a small limestone scar on Elbolton, 1000 feet above sea-level. The chamber, before the exploration commenced, was 30 feet long, and varied from 7 to 13 feet in width. The floor was fairly level, with the exception of a heap of stones under the entrance. On the surface nothing was observed but a few sheep bones of recent origin. The upper stratum, which varied in thickness from 4 feet at the east to 17 feet at the west end of the chamber, is the only one wherein human remains have yet been found. It consisted of loose angular fragments of limestone interspersed with large quantities of bones of the Celtic Shorthorn, the Horse, the Boar, Dog, Red Deer, Sheep, etc. The bones of the larger animals were split and broken, and were evidently used as food. Burnt bones and charcoal were found in three places. Three human skeletons were discovered buried with the legs bent and the knees close to the skull. The other human bones were more or less scattered. Most of the skulls were shattered, though two, obtained from the east end, are fairly preserved, and are good typical specimens of the *long head* type. But the human remains obtained from the other end of the chamber and at a much lower level, 13 and 15 feet below the floor (one lying but a few inches above the clay containing the bones of the Bear and Reindeer), are not dolichocephalic but brachycephalic. The latter are more decayed than the others. Associated with the round head was pottery of different character to that which was found in other parts of the cave. It is thicker, ruder, and with a different ornamentation. The pottery found near the long-headed men was marked with straight lines, in some cases cutting one another and forming a diamond-shaped ornamentation, in others going in and out without intersecting, forming a 'herring-bone' pattern. Others had impressions made by some rounded bone tool. But the pottery found near the remains of the round head is ornamented with wedged-shaped characters made with an angular tool. Both kinds of pottery were made from clay similar to that found in the cave, and both kinds were hand-fashioned without wheel, and charred and burned from the inside. No flints or metal of any kind have been found in the cave. The only objects obtained have been bone pins and a few other worked bones.

From the position where this brachycephalic skull was found, and from the ruder kind of pottery associated with it, it would appear that in Craven a round-headed race preceded the long-headed one.

Nearly all of the upper stratum containing human remains had been cleared away before August last, and the next layer had been worked for some distance, especially in the second shaft at the west end of the chamber. So far this lower stratum was composed of stiff clay, with angular fragments of limestone, and at times a thin bed of stalagmite. No human remains nor any of the animals associated with them have been found. These are replaced mainly by Bears, both *Ursus ferox* and *Ursus arctos*, and great numbers of Alpine Hares and Foxes. The bones in this layer show no evidence of

having been gnawed by other animals; they either perished in the fissure or their bones were washed down through pot-holes into the cave. The bones from the lower layer are darker, much harder, and less porous than those from the upper one.

After the meeting of the Association at Leeds the efforts of your Committee were first directed to the careful examination of the lower clay bed in the centre of the chamber. A pot-hole, about 10 feet deep and 3 feet in width, was cleared out. This contained a few of the limb bones of a Bear. A great part of the rock floor at the foot of the first ladder was blasted. It consisted apparently of a quantity of rock fallen from the roof and cemented by stalagmite. We were hopeful that underneath it we should find an old deposit. So far, however, it is solid. Further west the excavation was continued, the difficulty of working in the soft adhesive clay increasing. The percentage of bones was small, and in the next six feet not a single bone was found. The cave has now developed into a deep fissure, and is from 4 to 6 feet in width at a depth of about 45 feet from the original level of the cave floor. The attention of your Committee was next directed to find any possible entrance to the cave in addition to the present one: the floor was tested along the sides of the cave east of the first ladder, but the miners report that there the ground was all solid rock.

Between the barren clay section and the second ladder there is a quantity of unexplored material. Huge blocks of fallen rock are wedged in the fissure, and it was found unsafe to remove them as they underpin an immense overhanging side of the cave 60 feet in height. The second ladder was then descended, and a level driven beneath the fallen blocks at a depth of 45 feet from the first floor. For the first 6 feet this level was as ossiferous as any of the material yet examined, and of similar character, containing bones of the Bear and Hare. Beneath was a barren clay, followed by beds of sharp quartz sand, until the level is barred by solid rock. In the descent two or three stalagmitic floors were pierced, but the material continued the same above and below the stalagmite. The new chambers that were opened last year are extensions of this fissure. The miners have put a steel rod 8 feet lower than present level, forcing it through another stalagmitic floor. While the east part of this level is sand, containing no bones, the western part and the passage up to the new chamber is a breciated mass of bones and stalagmite.

At the further extremity of the new chambers, and about 60 yards from foot of second ladder, there was a deep pool into which the roof dipped. In the floor of the passage leading to the pool a hole 8 feet deep was dug. The material was comminuted limestone. Here also bones of young Bears were found. They had evidently been washed down from the first chamber. By means of this excavation the pond was lowered 4 or 5 feet. A ladder was placed across it, and an entrance effected into a further passage leading to a large natural chamber.

So far the cave has been interesting. What may be entombed in

the unexplored depths of the fissure is a matter of pure conjecture. Whether a repetition of the finds in the fissure at Ray Gill, and in the lower cave earth of the Victoria Cave, with the addition of Palæolithic man, must be left for future exploration to determine.

Your Committee request reappointment, and that a grant of £25 be made to assist in the further exploration of the cave.

## CORRESPONDENCE.

### NOTES ON CONISTON FLAGS.

Sir,—May I be allowed to point out that in my "Note on the Coniston Flags" in your last issue, the printer makes it appear that in microscopic work I made use of sections rather larger than are usually employed. Speaking of the garnets (p. 460), he makes me say that this mineral appears and disappears "within a few yards *along* the slide and a few feet *across* it."

Messrs. Voigt and Hochgesang, who make my sections for me, have very great skill in our work, but I do not think they could quite make slides of the size here indicated! What I wrote was *strike*, where the printer has put *slide*. W. Maynard Hutchings.

Newcastle-on-Tyne, *Oct.* 7, 1891.

### CONCRETIONS IN MAGNESIAN LIMESTONE.

Sir,—Has not Mr. Garwood omitted to consider a third possible method of origin for these and similar concretions? Infiltration and Segregation are not the only ways in which concretions are formed. Why should not the carbonate of lime have been obtained from the water above, while that particular bed was being deposited? It is not necessary to suppose that the carbonate of lime must have been deposited in the bed and then segregated; it is surely more likely that it was in solution in the water above, and was precipitated by chemical action. The ammonia or ammoniacal compounds evolved from decaying organic matter might be the initial cause.

A. J. Jukes Browne.

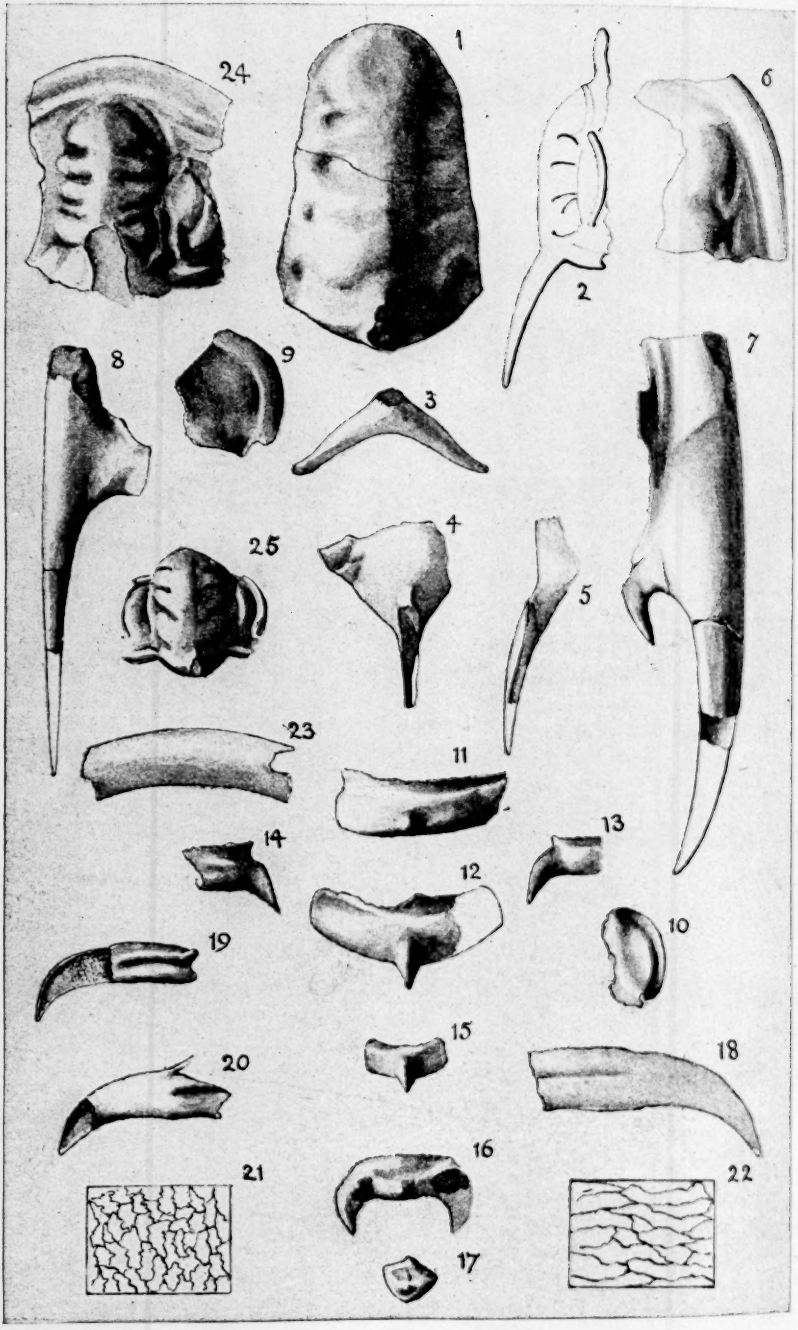
## OBITUARY.

With deep regret we record the following deaths:—

Charles Smith Wilkinson, F.G.S., F.L.S., V.P.L.S., N.S.W., the Government Geologist for New South Wales, who died at Sydney on 23rd August, 1891, aged 47 years.

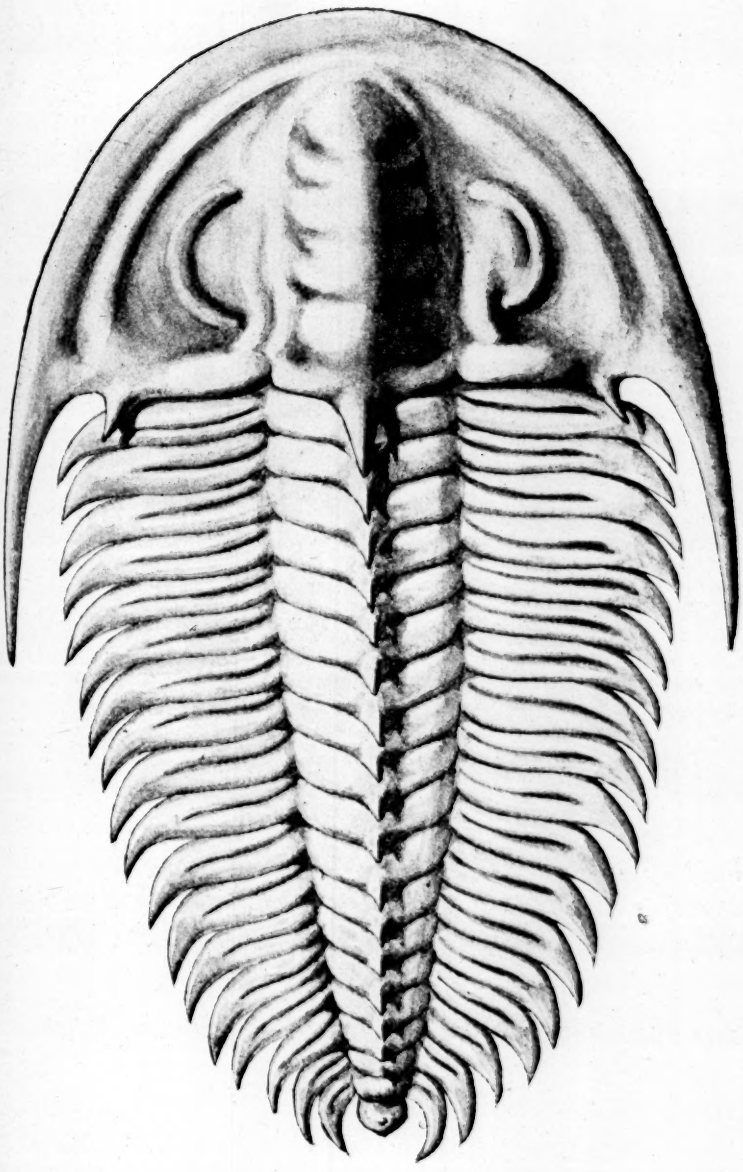
Philip Herbert Carpenter, D.Sc. (Camb.), F.R.S., F.L.S., Science-Master of Eton College, who died on 21st October, 1891, aged 39 years.

We hope to publish a fuller notice of these eminent geologists and palæontologists next month.




*E. C. Woodward, del.* *Meisenbach Co. sc.*

*Olenellus Callavei*, Lapworth,
from the Comley, or Hollybush Sandstone, of Shropshire.



*Olenellus Callavei*, Lapworth,

Comley, or Hollybush Sandstone of Shropshire.

Theoretical restoration, natural size.